THE OHIO JOURNAL OF SCIENCE

VOL. XXVI MAY, 1926 No. 3

PARASITES OTHER THAN CESTODES IN BLACK BASS OF OHIO.

RALPH V. BANGHAM,
College of Wooster.

While studying the cestode parasites of large- and small-mouth bass many other parasites were found and identified. Often certain of these were more injurious to the host than the cestodes present. This was especially true of the acanthocephala which were found most often in the adult fish and in the largest numbers. No attempt will be made to give complete records for each species of parasite, but sufficient data will be included to give distribution records and degree of infestation.

TREMATODE PARASITES.

Ancyrocephalus sp.

This gill parasite is either *A. paradoxus* (Crepl.) or *A. cruciatus* (Weld.)

Cooper (1915, p. 190) reported these species from gills of *M. dolomieu.*

J. Stafford, 1905, reported the occurrence of *Tetraonchus unguiculatus* Wag.—(*A. paradoxus* Crepl.) from *Ambloplitis rupestris* and *Eupomotis gibbosus.*

H. J. Van Cleve (1921, p. 37) reports light infestation on gills of *Lepomis pallidus, Ictalurus punctatus, Lepomis humilis,* and *M. salmoides* at the Fisheries Biological Station, Fairport, Iowa.

These were found on the gills of young large-mouth bass taken in the vicinity of Put-in-Bay and West Harbor, Lake Erie. The bass varied in length from 21–42 mm. There were from 5–20 of these trematodes on the gills of the fish found infested. Only a small proportion of the fish were infested.

Cryptogonimus chyli Osborn.

This form was described by H. L. Osborn in 1903 (p. 517–536), from fishes of Michigan and New York. The species was reported for *M. dolomieu*, from Lake Chautauqua, N. Y., and from St. Mary's River, Mich. It was also reported for *Ambloplitis rupestris* in Canadian waters by Stafford, '05.

The adults of this species were found in the pyloric caeca and upper intestine of nearly all the small-mouth bass, large-mouth bass, and rock bass examined. This trematode occurred as an adult first when the bass reached a size of 45–50 mm. They were not found sexually mature in younger bass, but were often found as skin and muscle cysts.

In northeastern Ohio many young bass were heavily infested with larval cysts of this form. These cysts were beneath the skin and between the fin rays. Mr. E. L. Wickliff and Mr. R. N. McCormick report thirty-six species of fish infested with these skin cysts. Their collections were made in northern Ohio during August and September, 1922. Their list follows:

Black Parasitic Skin Cysts (Immature Trematodes) *C. chyli* in Ohio Fish, Zoology Department Collection, Ohio State University.

Fish.

1. Common Sucker (Catostomus commersonii).
2. White-nosed Sucker (Moxostoma anisurum).
3. Quillback (Carpiodes velifer).
4. Small-mouth Bass (Micropterus dolomieu).
5. Large-mouth Bass (Micropterus salmoides).
6. Rock Bass (Ambloplites rupestris).
7. Green Sunfish (Lepomis cyanellus).
8. White Crappie (Pomoxis annularis).
9. River Chub (Hybopsis kentuckiensis).
10. Creek Chub (Semotilus atromaculatus).
11. Common Sunfish (Eupomotis gibbosus).
12. Golden Shiner (Notemigonus crysoleucas).
13. Log Perch (Percina caprodes).
14. Yellow Perch (Perca flavescens).
15. Stone Roller (Campostoma anomalum).
16. Johnny Darter (Boleosoma nigrum).
17. Sand Darter (Ammocrypta pellucida).
18. Black-sided Darter (Hadropterus aspro).
19. Rainbow Darter (Etheostoma coeruleum).
20. Fan-tail Darter (Etheostoma flabellare).
21. Green-sided Darter (Diplesion blennioides).
22. Storer's Chub (Hybopsis storerianus).
23. Black-nosed Dace (Rhinichthys atronasus).
24. Common Shiner (Notropis cronutus).
25. Steel-colored minnow (Notropis whipplii).
26. Blunt-nose minnow (Pimephales notatus).
27. Fat-head minnow (Pimephales promelas).
28. Sucker-mouth minnow (Phenacobius mirabilis).
29. Bullhead minnow (Cliola vigilax).
30. Emerald minnow (Notropis atherinoides).
31. Straw-colored minnow (Notropis blennius).
32. Shumard's minnow (Notropis shumardi).

The bass at Put-in-Bay were never heavily infested. Fifty skin cysts on a 65 mm. small-mouth bass was the maximum. The heaviest infestation was in Geauga County. McCormick reported a black-nosed dace (*Rhinichtys atronasus*) 75 mm. long with 420 cysts. A 70 mm. large-mouth bass from this county had 100 cysts. These two fish were collected August 10, 1922. An 85 mm. small-mouth bass collected August 16, 1922, Conneaut Creek, Ashtabula County, had a few skin cysts, and hundreds of these immature trematodes in the intestine and body cavity. The liver of this fish was riddled with large watery cysts of another trematode, *Clinostomum marginatum*.

An 87 mm. small-mouth bass from a brook near Tiffin had over 100 skin cysts. Other bass taken from various northern Ohio streams showed this infestation. The infestation was heavier in the minnows.

Crepidostomum cornutum (Osborn) 1903.

This trematode was described by Osborn (1903, p. 63–73) as *Bunodera cornuta*, but was later placed in the genus *Crepidostomum* Braun, 1900. This trematode was found frequently in the stomach of young and adult individuals of large- and small-mouth bass and rock bass in every locality where these species were examined.

Osborn 1903, described larval cysts of this form in the crayfish and established it as an intermediate host prior to the adult stage of this species in the fish. My work confirmed this in most cases. Cysts with emerging flukes were found in partially digested crayfish taken from the stomach of adult bass. In southern Ohio streams crayfish formed the chief article of diet and this form was abundant.

Young fish obtain this trematode very early. The cysts in this case must be carried by smaller crustaceans. The forms found in the young bass were in the stage of early sexual maturity.

This fluke was easy to stain and gave the best preparations of any of the trematodes studied. This distome was found in the stomach and pyloric caeca of nearly all small-mouth bass examined from the streams of southern Ohio. The numbers of parasites per fish ranged from 4–25. These parasites were often obtained early by the young fish. In a 15 mm. small-mouth bass taken June 26, 1922, six immature *C. cornutum*

were found in the stomach. They averaged .3–1.0 mm. in length. Many others were found in June and July from young bass 17–28 mm. in length. In one case an immature fluke of this species was found encysted in the liver of an adult smallmouth bass taken at Put-in-Bay.

Clinostomum marginatum Leidy, 1856.

This fluke was first reported in America by Leidy (1856) in the intestine of pike (*Esox lucius*) in the Delaware River and in cysts attached to the gills of the sunfish (*Eupomotis vulgaris*).

Braun (1900) in a revision of the genus recognizes eight species of the genus Clinostomum, among them *C. marginatum*. Osborn (1911), (p. 350–364), gives many records for the distribution of this form and among the hosts infected reports specimens of this fluke encysted in the muscle tissues of *M. dolomieu*, collected at Nebish, Michigan. He also records its occurrence in *M. dolomieu* taken at Troy, Ohio, from the Miami River. Some of these larval flukes were encysted in muscle and others in the skin on the internal aspect of the branchiostigal membranes. According to Osborn, 1911, these cysts were most abundant the latter part of August and early in September. Osborn (1911, p. 354) gives a table showing distribution records. The following additions can be made from my data.

Clinostomum marginatum.

Host	Adult	Locality	Number Parasites	Location in Host	Date
M. dolomieu	Adult	Little Miami Lebanon	8	cysts about tail	9–4–22
M. dolomieu	4.2 cm.	Sugar Isle Lake Erie	4	stomach cysts from food	7–11–22
M. dolomieu	8.5 cm.	Conneaut Creek Ashtabula	many	liver cysts	9–16–22
M. salmoides	30 cm.	Newtown Fish Hatchery	4	liver cysts	9–2–22
Eupomotis gibbosus	Adult	Put-in-Bay	many	liver riddled muscle cysts	7–25–22

These forms were all small and usually few in number. They were all sexually immature.

Leuceruthrus micropteri Goldberger, 1911.

The genus was described by Marshall and Gilbert (1905) and this form described from the black bass of Wisconsin and Indiana by Goldberger ('11). These flukes enter the bass quite early. All these flukes were found in the stomach. They were usually in larval condition. The most unusual occurrence was the finding of two of these adult flukes, one measuring 6.4 mm. in length and the other 7.4 mm. long, in a 17 mm. large-mouth bass examined June 28, 1922. They were sexually mature and had the uterus filled with eggs. All others found were larval or in early maturity. These forms were more often found in the large-mouth bass than in the small-mouth bass.

These flukes were found in small numbers. The heaviest infestation occurred in an 11.2 cm. large-mouth bass from West Harbor, Lake Erie. There were ten in the stomach. They measured 2.0–3.5 mm. in length. These were not usually obtained until the bass attained a length of 35–40 mm.

All of these distomes were found in bass obtained from various locations in Lake Erie. They were not found in fish taken at the State Hatcheries or from Ohio streams.

Azygia Looss, 1899.

Many records have been given for species belonging to this genus in *M. salmoides* and *M. dolomieu* as well as for other fish. All the flukes found belonging to this genus were in early sexual maturity.

Two of these parasites were found in the stomach of a 52 mm. small-mouth bass from Put-in-Bay. Six large-mouth bass from East Harbor had from 2–6 of these flukes in the stomach.

Microphallus opacus Ward, 1901.

This form has been reported for *M. dolomieu*, *Amia calva*, *Anguilla chrysypa*, *Ictalurus punctatus*, and *Perca flavescens*. As reported by Ward ('94) and Osborn ('02), this form has its earlier stage in crayfish, according to Ward: "in the space in the cephalothorax above the heart and sexual organs"—and Osborn says: "it is found invariably in the liver (of crayfish) whose effective area is frequently greatly reduced by the cysts."

My only findings for this species were in two large-mouth bass obtained at Paint Creek, Fayette County, Ohio. One specimen 28 cm. in length had ten of these parasites in the upper intestine. They measured .50–.85 mm. in length. The other bass measured 17 cm. and had six of these parasites in the upper intestine.

Nematode Parasites.

No attempt will be made at this time to describe or identify all the nematode species found in the large– and small-mouth bass. These parasites were never found in large numbers in the bass.

The adult small-mouth bass of southeastern Ohio were most frequently infested with intestinal nematodes. These were the largest forms found in the bass. They probably belonged to the family Ascaridæ. They have a mouth with three rather prominent lips, a smooth body and no spines. The females measure from 30–45 mm. and have an abruptly pointed posterior end. The males measure 20–35 mm. and have two prominent spirules of equal size.

In the young small-mouth bass at Put-in-Bay nematodes appeared late in the first season and never in large numbers. The form most often found was *Spinitictus gracilis* (Ward and Magath). Five were found July 17, 1921, in the intestine of a 50 mm. small-mouth bass. Other nematodes of this species were found in larger small-mouth bass, but never in large numbers.

No nematodes were found in 1922 until July 15 and then only in about one-third of the young fish examined during the season. In some of the bass many encysted forms were found belonging to the family *Filariidæ*.

The large-mouth bass had likewise few nematode parasites. More encysted Filaria were found, these after the bass had reached 30 mm. in size.

In the intestine of a 10 cm. large-mouth bass from West Harbor, obtained July 12, 1922, two nematodes belonging to the genus Camallanus were found. Similar individuals were found in a few other large-mouth bass. In a slide labeled "Young small-mouth nematodes," July 20, 1921, Put-in-Bay, two individuals of this genus were present.

Acanthocephala.

This group of parasites has been studied for the bass as well as other hosts by Van Cleave ('13 and '19, a and b). Acanthocephala were often found in large numbers attached to the inner wall of the intestinal tract of adult bass. They were more prevalent in small-mouth bass. In younger bass one form, *Echinorhynchus thecatus* Linton, 1891, was often found encysted in the mesentery and pyloric caeca. This species was the one found in largest numbers in adult bass.

E. thecatus and *N. cylindratus*.
Measurements in cm.

Host	Size	Date	Locality	N. cyl. in host	E. the. encysted	E. the. in int.
M. salmoides	3.6	7–15–21	W. H.			1
" "	13.5	7–15–21	W. H.			Many
" "	4.9	7–26–21	E. H.	1		1
" "	15.0	7–26–21	E. H.	7		2
" " 17 spec.	4.5–6.0	.8– –21	Akron Hatchery	few	1–10 in viscera	2–25
M. salmoides	3.1	7–12–22	W. H.	1		
" "	2.9	7–12–22	W. H.	1	3 pyl. caec.	
" "	3.5	7–12–22	W. H.			2
" "	3.6	7–14–22	W. H.	1		1
" "	3.1	7–19–22	P-i-B	3	2 mes.	
" "	17.0	7–26–22	Akron Hatchery	20		3
" "	17.0	8–8–22	London Hatchery	1		
" "	5.6	8–27–22	P-i-B		5 mes.	
" "	9.5	9–13–22	W. H.	few int.	5 mes. 2 pyl. caec.	
" "	18.5	9–8–22	Fayette Co.	many int.		

E. H.—East Harbor.
W. H.—West Harbor
P-i-B—Put-in-Bay.

Van Cleave '20, studies the life history of *E. thecatus* and says regarding this: "Larvæ of *E. thecatus* have been found in *Hyalella knickerbockeri*. The young bass fed on these amphiopods acquire a general infestation of *E. thecatus*." He also says ('20, p. 170), after discussing the amphipod as the intermediate host: "Data from other sources furnish incontestable evidence that one or more intermediate hosts may be intercalated between the primary and the definitive hosts of *E. thecatus*. Larvæ which unmistakably belong to this species have been encountered frequently encysted in the viscera of various fishes."

In my studies none of the encysted forms were found until the bass began to eat amphiopods. No encysted *E. thecatus*

E. thecatus and *N. cylindratus*.
Measurements in cm.

Host	Size host	Date	Locality	N. cyl.	E. the.	Degree of infestation in E. the.
M. dolomieu	4.0	7-6-21	P. B.		int.	medium
" "	6.0	7-18-21	P. B.	2		
" "	12.5	7-18-21	P. B.		int.	6
" "	6.4	7-20-21	P. B.	1	int.	1
" "	5.8	7-22-21	P. B.	3		
25 " "	18-35	9- -21	Clinton and Green Counties	few	int.	medium to heavy
" "	10.0	7-4-22	P. B.	20	int.	light
" "	18.5	7-9-22	P. B.		int.	50
" "	23.0	7-15-22	P. B.		int. pyl. caeca	heavy 300
" "	3.5	7-19-22	P. B.	2	int.	1
" "	11.0	7-19-22	P. B.	3		
" "	20-34	7-27-22	P. B.	few	int. pyl. caeca	heavy
" "	6.5	8-26-22	P. B.	4	int.	2
" "	15-32	10- -22	Clinton and Green Co.	few	int. pyl. caeca	medium

P. B.—Put-in-Bay.

were found in the small-mouth bass of Put-in-Bay where there are few amphiopods in the diet of the bass.

Nearly all adult large- and small-mouth bass examined contained *E. thecatus* in numbers ranging from 1 to more than 200. They were found in about equal numbers in the adult bass from Lake Erie and southern Ohio. They were more abundant in bass examined in the fall.

The other species found in the large- and small-mouth bass was *Neoechinorhynchus cylindratus* Van Cleave, 1913. This species was found from many localities in large- and small-mouth bass, but never in large numbers. They were not found in the encysted stage, but always free in the intestine. The following tables give some idea of the time of infestation in young bass.

Parasitic Copepods.

Two species belonging to the family Ergasilidæ were found attached to the gills of large- and small-mouth bass in a few cases. There were never more than three or four of these parasites per fish. In all, not more than thirty of these parasites were found in all of the fish examined. The Ergasilidæ in North America were studied and new species recorded by Wilson ('11).

One species of Lernaeidæ was occasionally found attached to the host. Usually but one specimen was found on a host and but few bass were infested with this form.

Discussion.

The parasites which were most injurious to the bass in addition to the cestode parasites, *P. ambloplitis* and *P. fluviatilis*, were, the trematodes which infest the liver, skin and muscles, and those acanthocephala which are found encysted in the mesenteries in immature stages and as adults attached to the intestinal mucosa.

In young bass the most evident damage was done by forms which infest the liver and mesenteries such as was evident in a few cases where *Clinostomum marginatum* were found in large numbers, and by the encysted forms of *E. thecatus*. The size of a badly infested fish as compared with others of the same age, and the amount of fat in the mesenteries were criteria for estimating the damage. The more the retardation in development of the fish, the greater opportunity there is for

this fish to be eaten by bass or other carnivorous forms. In older fish the vitality is often much lowered by parasitism.

A small-mouth bass three years old which died at the Akron Hatchery was examined and found to be very heavily infested with *E. thecatus* in mesenteries and adults of the same species in the intestine. The fish was 12 cm. in length and weighed but 14 ounces. Several other fish were found in almost the same condition. Some had their gonads destroyed by a larval cestode *P. ambloplitis*.

Considerable damage was reported in adult bass taken in northwestern Ohio, due to skin and muscle cysts of *C. marginatum* and *C. chyli*. In many cases these fish were unfit for food. Too few of these badly infested fish were examined to give data as to the extent of this infestation.

Parasitism seems to be of considerable importance at certain of the inland fish hatcheries. At the Newtown and London hatcheries very few infested fish were found and those that were found were usually the adult fish brought in from some other location. Perhaps the intermediate hosts had not become established. At the Akron hatchery there was marked infestation of both large- and small-mouth bass. In general the infestation of young bass was much heavier than those studied from Lake Erie in the vicinity of Put-in-Bay. More work should be undertaken regarding the importance of parasitism as a limiting factor at the fish hatcheries.

BIBLIOGRPAHY.

Braun, M.
1894–1900. Vermes: Cestodes. Klassen und Ordnungen des Thierreichs, 4, Abt. 1, b.

Cooper, A. R.
1915. Trematodes from Marine and Fresh Water Fishes including one Species of Ectoparasitic Turbellarian. Trans. Royal Soc. Canada, Sec. IV, (III) 9: p. 181–205.

Goldberger, Joseph.
1911. Some Known and Three New Endoparasitic Trematodes from American Fresh Water Fish. Bull. 71, Hyg. Lab. Pub. Health, Mar. Hospital, Serv. Wash. p. 7–35, 5 pl.

Leidy, J.
1887. Notice of some parasitic worms. Proc. Nat. Acad. Sci. Phila. 39: p. 20–24.

Marshall, W. S., and Gilbert, N. C.
1905. Three New Trematodes found principally in Black Bass. Zool. Jahr. Abt. Syst. Bd. 22: p. 476–488, 1 pl.

Osborn, H. L.
1903. Bunodera cornutum sp. nov. A New Parasite from the Crayfish and Certain Fishes of Lake Chautauqua, N. Y. Biol. Bull. Vol. 51, p. 63–73.
1903. Cryptogonimus (N. G.) Chyli (n. sp.). A fluke with two ventral suckers. Zool. Anzeiger, Vol. 26: p. 695–696.
1910. On the structure of Cryptogonimus (N. G.) Chyli (n. sp.). An aberrant distome from fishes of Michigan and N. Y., Jour. Exp. Zool., Vol. IX, No. 3: p. 517–563, 7 Fig.
1911. On the Distribution and Mode of Occurrence in the United States and Canada of Clinostomum marginatum, a Trematode Parasite in Fish, Frogs and Birds. Biol. Bull. Vol. XX, p. 350–366.

Stafford, J.
1905. Trematodes from Canadian Vertebrates. Zool. Anz., 28: p. 681–694.

Van Cleave, H. J.
1913. The Genus Neorhynchus in North America. Zool. Anz. 43: p. 177–190.
1916. Seasonal distribution of some Acanthocephala from fresh-water hosts. Jour. Parasitol. 2: p. 108–110.
1919. a. Acanthocephala from the Illinois River, with descriptions of species and a synopsis of the Family Neoechinorhynchidæ. Bull. Ill. Nat. Hist. Survey. 13: p. 225–257.
1919. b. Acanthocephala from Fishes of Douglas Lake, Mich. Occas. Pap. Museum Zool. Univ. Mich. 72: p. 1–12.
1920. Notes on the life cycle of two species of Acanthocephala from fresh-water fishes. Jour. Parasitol. Vol. VI, No. 4: p. 167–172, 1 pl.
1921. Trematodes from Fresh-Water Fishes. Jour. Parasitol. Vol. VIII, p. 33–39.

Ward, H. B. and Magath, T. B.
1917. Notes on some Nematodes from Fresh-Water Fishes. Jour. Parasitol. 3: p. 57–64. 1 pl.

Ward, H. B., and Whipple, G. C.
Fresh-Water Biology. Wiley & Sons. N. Y., p. 401.

Wilson, C. B.
1911. North American Parasitic Copepods Belonging to the Family Ergasilidæ. Proc. U. S. Nat. Museum, 39: p. 263–400. 20 pl.

THE NATURAL VEGETATION OF OHIO

II. THE PRAIRIES

PAUL BIGELOW SEARS,
Department of Botany, The University of Nebraska.

INTRODUCTORY STATEMENT.

It is well known that many treeless areas existed in Ohio before white settlement. These areas, of various ecological character and usually restricted in size, were in a few cases fairly extensive—embracing from fifty to one hundred square miles. The term "prairie" was rather generally applied to them, although more exact terms were not wanting. Like the various forest associations, these treeless areas have played an important rôle in influencing industrial and cultural phases of human life in Ohio (1). The present paper is an attempt to reconstruct such areas, now destroyed or obscured by secondary successions induced by white men. In this as in the preceding paper on the virgin forests of Ohio (2) the question of succession has been intentionally postponed.

The sources consulted in this work are essentially those drawn upon for the preceding paper, towit, field notes of original surveys, county and other local histories, accounts of travelers and pioneers, and occasional papers by the early naturalists who knew this region. Taken together all of these supply a fair system of checks. In many cases also the writer's own field observations have been of service, since isolated remnants are still to be found along roadways and elsewhere.

In addition to the friends whose assistance has been earlier acknowledged, the writer wishes to express his gratitude to Mr. Emory C. Leonard of the U. S. National Herbarium, who kindly consented to check the numerous synonyms in the floristic lists. Thanks are also due to Miss Clara G. Mark for suggestions in relation to physiographic problems.

WORDS USED TO DESIGNATE TREELESS AREAS.

As stated above the term "prairie" in the early records meant a treeless area, generally grassy, but sometimes covered with low shrubs or brush. It might be wet or dry. The following terms seem to have been somewhat narrower in their meaning.

Wet Prairie.—Equivalent to wet meadow, generally consisting of sedges, rushes, and grasses, e. g., *Phragmites* and *Calamagrostis*. It was sometimes extended to include cattail and pickerel weed associations, and not infrequently used to indicate bog meadow, i. e., "cranberry prairie."

Figure 1.

Position of the treeless areas of natural vegetation in Ohio. Based upon records made between 1750 and 1850, and checked in many cases by field observations. Symbols indicate character as designated in early records.

Dry Prairie.—One in which no standing water was found; most frequently the marginal zone of a wet prairie if the nearby trees were sparse; in some cases merely the late summer aspect of a normally wet prairie; at times perhaps the more or less direct result of fire.

Bog.—Largely in the modern sense, referring to a depression filled or filling with peat, the product of a boreal flora.

Swamp.—Habitat marked by standing water for most of the year, occupied either by herbs (aquatics such as cattails and pickerel weed, etc.), shrubs (small willows, alders, buttonbush, etc.) or trees (ash-elm, tamarack-alder, etc.).

Swale.—Apparently a small swamp.

Marsh.—An herbaceous swamp, generally an extensive one; also used specifically to designate the bog meadow, e. g. "cranberry marsh."

Barren.—An habitat in which tree growth is scrubby, defective, or even absent; used alike in cases of deficient and excessive soil moisture.

Oak Opening.—Essentially oak savannah, the oak forming open thin groves, or being present as scattered clumps or individuals, with the (generally lower) ground between occupied by grasses and other herbaceous vegetation.

EXPLANATION OF THE MAP.

The foregoing glossary is not ideal, but it represents just what we have for our work. With the accompanying map, Fig. 1 (1922 U. S. G. S. relief map of Ohio) will be found a key to the conventional signs used. These signs, centered upon the habitat they designate, are a key to position and quality, but not to size of habitat. It will be noted that "swale" and "marsh" have not been used, but the remaining terms are used in as near their modern restricted sense as available descriptive records will allow. Upon this basis selection has been made between synonyms where possible. In certain cases it is not clear whether two terms were intended as synonyms—they may have referred to two adjoining but differing associations or to different seasonal aspects of the same area. In these and all other cases of too meagre information the map has entered upon it just what the records say, and with this we must rest content. It will be noted that there is a symbol for questionable or uncertain cases which has been freely employed.

It should be explained that all of the "swamps" marked in Preble County and several of those in Delaware, as well as the "bog" on the lake shore in Lake County were wooded, and not at all treeless. There has been no attempt to map all bogs—chiefly those are shown whose bog-meadow stage earned them at one place or another in the records the name of "prairie."

The bogs of Ohio have, of course, been studied in detail by Dachnowski (3) to whose work the reader is referred.

While most of the symbols represent patches of small area there seem to have been no less than five regions in which the prairies were of considerable size in the aggregate. These coincide with areas marked "Oak" in the virgin forest map (2). First, there was the sandy region of Fulton, Lucas, and Wood counties; second, the thin-soiled limestone region of Sandusky, Erie, Seneca, and Huron; third, the sandy region of oak openings in Wayne and Stark counties; fourth, the Wyandot and Sandusky Plains of Wyandot, Marion, and Crawford counties; fifth, the Darby Plains of Union, Madison and adjacent counties. If to these we could add the marginal wet meadows along Lake Erie, the grass-covered depressions within the Erie Basin and upon the divide, the chains of "cat-head" prairies in the filled valleys of the two Miamis, the Scioto, and the Licking, the resulting total would at least cover two average counties. Fifteen hundred square miles represents a rough, but conservative estimate of the total natural treeless area in Ohio.

PRAIRIES AND PHYSIOGRAPHY.

Comparing the position of the treeless areas as marked in Fig. 1 with the physiographic boundaries in Ohio shown in Fig. 3 of the preceding paper of this series (2), certain general correlations at once appear. These are, briefly, as follows:

1. Treeless areas were practically absent from the unglaciated portion of the state.
2. They occurred all along the Ohio-Erie Divide, but in groups rather than at random.
3. These groups swung away to the southeast of the Divide in a series of crescent-like extensions.
4. North of the Divide the Erie Plain contained a series of curving groups, the innermost being along the present margin of Lake Erie.

From the fact that prairies were found only in the glaciated region one is justified in expecting a relation between glaciation and prairies. The parallel crescentic arrangement of these treeless areas suggests at once a correlation with the system of glacial moraines, (see Fig. 2). In most cases radii of these arcs approximate the direction of glacial movement, as can be verified by studying a map of the glacial striæ in Ohio. Like

the accompanying Oak of the virgin forest, then, the prairies in general occupied the regions near the apices of the glacial fronts, where outwash and ponding were the rule. As concrete examples of such habitats may be cited pondings in Mercer and

Figure 2.

Relation of the natural treeless areas of Ohio to the system of moraines as traced by Leverett in U. S. G. S. Monograph 41. Note the correlation with regions of glacial outwash and ponding. Consult Fig. 1 for symbols not visible here.

other counties, flats in Marion County, and filled preglacial valleys, whether silted and ponded as along the Miami, or gravel-filled and presumably overdrained, as in Pickaway County. Unlike the Oak the prairies occupied the actual depressions, although in their dryer phase they extended upward

towards and even into the Oak on higher ground. Besides these generally apical positions, prairie was found associated with Oak in the sand dune and pan of Lucas and Fulton counties, and the limestone ridge and shallow basin of Sandusky County.

Apart from the dryer ridges or marginal zones and the coarse gravel beds most of the prairies must at one time have been sites of either definite lakes, or seasonal ponding. There is no reason to doubt that Ohio has metamorphosed through the familiar postglacial stages now found farther north, in Michigan, Minnesota, and Canada. Orton (4) found evidence of a former extensive shallow lake upon the region occupied by the Darby Plains in Union and Madison counties. Numerous soil borings made by the writer upon former prairie sites have shown a layer of blue hardpan, generally close to the surface. Moreover, a large number of these areas are shown by the sheets of the Topographic Survey to possess a fall of considerably less than ten feet to the mile.

SURVEY OF PRAIRIE HABITATS.

Within the Erie Plain proper were found four distinct zones or belts of treeless areas, corresponding to the present or 5th beach of Gilbert (5), the 4th, 2nd, and 1st. The 3rd beach was not so well marked in this way, (cf. Fig. 3).

Two of these curving beaches, the 2nd and 4th, ran into sand hills at their northern end, resulting in oak openings on the dunes and wet meadows in the pans. Bogs were present in the two oldest beach zones but not in the younger ones. At their eastern end the beaches converge somewhat as they approach and cross the bare limestone ridge which runs southward from Sandusky Bay. Upon this ridge were found open groves of scrubby oak, while the shallow soil upon its flanks showed prairies, wet in some cases, as at Castalia, and probably dry in others.

Between the sandy northern and rocky eastern ends the beach lines curve across the broad flat Maumee Valley formerly occupied by Lake Erie—the Black Swamp Region. Here at intervals were prairies, generally wet. In Wood County, (6a), Van Wert, (6b), and Huron counties especially these prairies had the shape of old estuaries or baymouths similar to the present Sandusky Bay, for example.

The Erie Plain corresponds closely to the Erie Basin, save at the eastern end, where the present Ohio-Erie Divide lies some distance south of the escarpment near the lake which separates Erie Plain from Alleghany Plateau. Upon the intervening strip

Figure 3.

Relation of natural treeless areas of Ohio to preglacial drainage lines and postglacial lakes. Shores of postglacial lakes in Erie Basin shown in white; preglacial valleys in wide black (approximations in narrow black). White arrows indicate beach sand, black arrows small postglacial lakes. See text for further explanation.

of plateau prairies were quite lacking. Along the divide, however, prairies abounded, mostly being depressions or inadequately drained flats. These prairies of the divide fell into at least five distinct constellations or groups, each of which curved

away to south and east as already noted. These groups were found in Mercer, Hardin, Wyandot-Marion-Crawford, Ashland-Wayne, Wayne-Stark-Summit, with perhaps a sixth group in Portage-Mahoning and a seventh in Trumbull County. In at least Mercer, Ashland, Stark, and Wayne counties all or many of these wet prairies marked the course of deep, buried and silted preglacial drainage valleys, as is shown by Fig. 3. The position of preglacial drainage lines shown by this map is based upon various sources, including work by Read (7), Tight, Bownocker, et al. (8), Clark (9), and Tight (10).

Moving southward from the divide there were left four principal regions of prairie—Miami Valley, Miami-Scioto uplands (Darby Plains), Scioto Valley, and Licking Valley. All of these regions coincided at least in part with great preglacial valleys (Fig. 3), now silted or gravel-filled. That the Darby Plains represented a shallow postglacial lake site has already been mentioned. A somewhat isolated prairie in northern Clinton County is known to lie in a buried valley.

In brief then, there were prairies within the Erie Plain, along old shore lines and in ancient bays; prairies along the Ohio-Erie Divide, many of which were within buried valleys or the sites of postglacial lakes; and prairies in the glaciated Ohio Basin, of which the same statement may be made. In the face of such correlations, any serious attempt to invoke fire as a prime cause of Ohio prairies must vanish, although fire doubtless played a rôle in their history. That these more detailed correlations are not inconsistent with the general morainal relations pointed out earlier, a little reflection will show. The major outlines of glaciation were fundamentally affected by preglacial topography, as were the details of outwash channels, etc. This point, made clear for Ohio by Read (7) and others is reiterated because of the frequency with which explanations involving "accidental" pondings and other topographic features were encountered early in this study. *There have been no accidents.* In fact, so striking is the relation between preglacial topography and natural vegetation that the writer does not hesitate to express his belief that a great preglacial valley will probably be found running northward through Champaign, Logan, Hardin and Hancock counties and another northwestward through Marion and Wyandot counties.

GENERAL APPEARANCE OF THE ORIGINAL PRAIRIES.

A portrait of the prairies is to be found in Cincinnatus (11). Evidently a composite account, it applies well to Ohio conditions. Grasses, including *Andropogon furcatus*, *Spartina*, *Eragrostis*, were said not to be turf formers. Flowers were abundant, but represented a profusion of individuals rather than species. Early aspects showed numerous legumes, *Baptisia*, *Desmodium*, *Psoralea*, *Dalea*, *Petalostemon*—some Rosaceæ, e. g., *Rosa*, and *Spiraea*, while from July to October Compositæ outnumbered all other orders. During this aspect *Actinomeris*, *Coreopsis*, *Helianthus*, *Rudbeckia*, *Lepachys*, *Echinacea*, *Liatris*, *Silphium*, etc., were conspicuous. Under conditions of settlement *Phleum*, *Agrostis*, and *Poa* were rapidly replacing all native plants.

From among numerous non-technical accounts which are available a few have been selected below for the graphic impression they give of the undisturbed treeless areas.

Christopher Gist, exploring southeast Ohio in 1751 (12) reported it full of beautiful natural meadows covered with wild rye, blue grass and clover (!), abounding with turkeys, deer, elk, and especially buffalo. This was in January and February. In March, travelling along the Little Miami, he noted that the river continued to run through the middle of a fine meadow about a mile wide, "very clear like an old field and not a bush in it."

Pease, surveying the 6th meridian (13) in 1796, between what is now Geauga and Trumbull Counties, came "to an intervale with grass, scattering trees, etc. * * * on this intervale is elm, white oak, ash, white thorn, elder, the white and red meadow plumb trees full of fruit (Sept. 6), which is ripe and excellent of the kind * * * the grass here would make tolerable hay and is generally a good burthen * * * bottom (of adjacent stream) hard clay and gravel."

Mr. C. E. Custis, describing to the writer the prairie in northern Clinton County, said that his mother came there in 1803 and in riding to school she often found the grass as high as her horse and head. There were some scattering clumps of trees. Cattle frequently mired in the "lower" prairie. In 1869, when Mr. Custis bought his present place, the "upper" prairie had been slightly drained and was covered with wild rose bushes, grasses, and some wild plums.

Cyrus P. Bradley (14) travelling through Ohio in 1835, says concerning the Pickaway Plains, "Our farmer described with great enthusiasm the appearance of these plains when he first pitched his tent upon its border. A natural plain of from three to seven miles in extent, covered with a low wild plum producing a luscious fruit, and without a single tree in its whole extent to obstruct the view." Trees were later introduced. If one visits Pickaway Plains today and examines the walls of cellars and other excavations he learns that the whole is underlain by many feet of pure, coarse gravel.

The same traveller, proceeding from Marion to Sandusky, says "Our road lay through low prairies and wet of course. * * * Prairie land is not necessarily wet or low. * * * But the prairies we passed over today are what we might call meadows; very low and wet, incapable of being drained, in a state of nature, unsusceptible of improvement. They are used for grazing and are exceedingly profitable. * * * In one instance we turned from the road and waded through the long grass of the prairie for miles, preferring a foot of unadulterated water, for it stood to that depth on the surface of the ground, to as great or greater depth of mud. * * * I shall never forget my ride across those gloomy unhealthy prairies which produce nothing but long grass, horned cattle, disease, mosquitoes, and rattlesnakes. One species of meadow grass was shown to me which is given the singular cognomen of Roman Catholic Grass.* Why, I did not learn."

The historian of Madison County (15) records that it is "well authenticated that a great portion of Madison County was originally covered with water most of the year. The first settlers called these lands barrens and looked upon them as utterly unfit for farming purposes. * * * The prairies consisted of level stretches of country covered with sedge-grass, and dotted here and there with patches of scrubby burr-oak growing upon the highest points of land. The sedge-grass grew to an enormous height, sometimes sufficient to hide man and horse when travelling through it; but [was] very nutritious for stock. * * * Nearly every autumn prairie fires swept over the country, destroying everything in their path. * * * But * * * these fires grew less frequent. * * * Timber on the east bank of the streams was always

*_Hierochloe odorata_ is native to Ohio, but is not listed by Schaffner (17) for the counties between Marion and Sandusky.

the largest, as these fires generally ran from west to east. * * * The growth of the burr-oak on the prairies was impeded by these periodical fires, and the greater amount of the present timber * * * has grown up since." The same authority quotes at length from an early physician, Doctor Converse. In vivid if empirical description is emphasized the extent and variegated color of the prairies. Three species of grass seem to have been dominant, one doubtless *Phragmites*, on the lower portions; two apparently including *Andropogon* on the upper. Numerous dicots are mentioned, notably *Silphium terebinthinaceum*, *Helianthus* sp., also *Iris*, *Lilium*, etc.

To Mr. Ephraim Monnette, born about 1835 on the Sandusky Plains between Bucyrus and Marion, the writer is indebted for a keen and intelligent verbal description of this region. At Tobias, toward the center of the area was a "Big Spring" of about one acre, covered by a floating sod of "moss," under which were fish and in which cattle were often mired. This was a dependable source of water the year round, even in very dry times. Just what this "moss" was would be a very interesting thing to know, but there is now no way of learning. To the writer's knowledge there were a number of other ponds, spring-fed, in this district.

Higher than the ponds, but still very wet, were the "prairies" proper. Their chief grass was quite tall, grew in tussocks, and possessed a "frizzly" head, on top of a hollow jointed stem. This was certainly *Phragmites*. Duckweeds were also described unmistakably, while *Lobelia*, quaking asps, slippery elm and "p— elm" were designated by name.

The so-called "plains" were dryer than the preceding. They bore strawberries in profusion, thorns, wild plum, puccoon root (white and yellow), wild turnips, indigo, rosin weed, sunflower, etc. The coneflower (*Rudbeckia*) made its appearance wherever the hogs rooted. In these dryer "plains" a shorter grass, described as having a defective or concealed head (possibly *Andropogon scoparius*) was dominant.

Upon the higher ridges or "islands" were oak, especially jack oak and hickory, also thorn, grape, hazel, (wild roses) and wild plums everywhere.

In early days these Sandusky Plains were drained by the Scioto, which was uncertain and feebly marked. Since lowering of the water table by drainage the stream has been growing and its channel deepening. Where the prairies have been disturbed,

blue grass has supplanted the original grasses. This phenomenon has been observed many times before and since.

If one today wished to see the conditions indicated in the preceding descriptions it would be almost impossible to find the fringing shrub zone of plum, rose, thorn, grape and hazel within Ohio, at least in its typical form. Very characteristic wet prairies can still be observed between Fremont and Port Clinton at the western end of Sandusky Bay, but the lowering of the water table has practically obliterated them inland. Drainage has not reacted so unfavorably upon the dryer phase, of which numerous examples can still be found in unbroken roadside sod throughout the former prairie regions of the state.

FLORISTICS OF THE ORIGINAL PRAIRIES.

In a publication now somewhat difficult to obtain (16) Riddell gives an extensive list of Ohio and other "western" plants, often specifying habitat and distribution—as they were known in 1835. Although settlement had progressed steadily at that date it is certain that many important prairie areas were still largely in their original condition. Riddell's list then is perhaps our best key to the floristics of the early prairies, but considerable scrutiny has been required to make it usable. All plants not definitely stated to be found in Ohio have been omitted, which accounts for the absence of *Andropogon furcatus*, *Calamagrostis* and a few other important forms which we know were present in great numbers. Plants from each type of treeless habitat have been grouped alphabetically. As far as possible all names have been conservatively modernized; where this has involved a change the old name used by Riddell will be found in parenthesis. In some cases where Riddell gave no authority the presumptive authority has been added. The numbers are his serial numbers, while asterisks mark those plants not listed in Schaffner's Catalog of Ohio Plants (16) or its supplements.

Plants of Ohio Barrens, after Riddell, 1835.

967 Brauneria purpurea (DC.) Britt. (Rudbeckia purpurea Willd.)
1078 Cornus paniculata L'Herit.
466 Corylus americana Walt.
1216 Gerardia pedicularia L.
736* Ilex lanceolata (Pursh) Chapm. (Prinos lanceolatus Pursh).
842* Liatris gracilis Pursh.
460* Quercus ilicifolia Wang. (Q. bannisteri Michx.)
459 Q. prinoides Willd. (Q. chinquapin).
448 Q. stellata Wang. (Q. obtusiloba).
461 Q. triloba Michx.
364 Tephrosia virginiana (L.) Pers. (Galega virginiana).

Plants of Ohio Bogs, after Riddell, 1835.

1436 Cypripedium hirsutum Mill. (C. spectabile Swartz).
1675* Eleocharis capitata (L.) R. Br. (Scirpus capitatus L.).
1684* E. simplex (Ell.) A. Diet. (Scirpus simplex Ell.).
1445 Juncus acuminatus Michx.
770 Lobelia puberula Michx.
769 L. siphilitica L.
1692 Rynchospora alba (L.) Vahl.
1693 R. glomerata (L.) Vahl.
617 Sarracenia purpurea L.
757 Vaccinium macrocarpon Ait. (Oxycoccus macrocarpus Pursh).

Plants of Ohio Dry Prairies, after Riddell, 1835.

1462 Allium cernuum Roth.
1649 Andropogon scoparius Michx.
21 Angelica atropurpurea L. (A. triquinnata).
23* A. lucida L.
1105 Apocynum cannabinum pubescens (R. Br.) DC. (A. pubescens Brown).
1094 Asclepias tuberosa L.
1092 A. verticillata L.
870 Aster laevis L. (A. cyaneus Pursh).
860 A. linariifolius L.
886 (A. miser L.)
869 A. novæ-angliæ L.
880 A. puniceus L.
321* Baptisia alba (L.) R. Br.
967 Brauneria purpurea (DC.) Britt. (Rudbeckia purpurea Willd.).
941 Cacalia atriplicifolia L.
417 Cassia chamæcrista L.
536 Ceanothus americanus L.
827 Cirsium discolor (Muhl.) Spreng. (Carduus discolor Nutt.).
826 C. muticum Michx. (Carduus glutinosus Bk.).
20* Coelopleurum actæifolium(Michx.)Coult.& Rose. (Ligusticum actæifolium).
1128 Convolvulus sepium L.
75 Delphinium exaltatum Ait.
349* Desmodium lævigatum (Nutt.) DC. (Hedysarum lævigatum).
361 D. obtusum (Muhl.) DC. (H. obtusum).
362* D. strictum (Pursh) DC. (H. strictum).
1253* Dyschoriste oblongifolia (Michx.) Ktze. (Ruellia oblongifolia Michx.).
508 Euphorbia corollata L.
210 Gaura biennis L.
211* G. parviflora Dougl. (G. mollis).
1218 Gerardia tenuifolia Vahl.
963 Helianthus giganteus L.
960* H. scaberrimus Ell.
965 H. strumosus L.
957 H. tracheliifolius Mill.
1113 Houstonia longifolia Gærtn.
165 Hypericum prolificum L.
1130* Ipomoea macrorhizus Michx. (Convolvulus macrorhizus Michx.).
937 Kuhnia eupatorioides L. (K. critonia L.).
972 Lepachys pinnata (Vent.) T. & G. (Rudbeckia pinnata Michx.).
344* Lespedeza angustifolia (Pursh) Ell.
340 L. capitata Michx.
345 L. hirta (L.) Hornem. (L. polystachia).
341 L. violacea (L.) Pers.
346 L. violacea (L.) Pers. (L. divergens).
838 Liatris spicata (L.) Willd.
839 L. squarrosa Willd.
772 Lobelia spicata Lam. (L. claytoniana Michx.).
223 Oenothera fruticosa L.

802 Prenanthes altissima L. (P. ovata Ridd.).
795 P. aspera Michx. (P. illinoiensis Pers.).
796 P. racemosa Michx.
566 Ptelea trifoliata L.
1284 Pycnanthemum virginianum (L.) Durand & Jackson. (P. lanceolatum Pursh).
970 Rudbeckia fulgida Ait.
968 R. hirta L.
969 R. triloba L.
1011 Silphium laciniatum L.
1010 S. laciniatum L. (S. gumniferum Ell.).
1009 S. terebinthinaceum L.
1012 S. terebinthinaceum pinnatifidum (Ell.) Gray. (S. pinnatifidum Ell.).
1006 S. trifoliatum L. (S. ternatum L.).
919 Solidago rigida L.
918 S. tenuifolia Pursh.
1651 Sorghastrum nutans (L.) Nash. (Andropogon nutans L.).
1398 Tradescantia virginica L.
1629 Tridens flavus (L.) Hitchc. (Tricuspis seslerioides Torr.).
1061 Triosteum perfoliatum L.
985 Verbesina helianthoides Michx. (Actinomeris helianthoides Eat.).
1068 Viburnum pubescens (Ait.) Pursh.

Plants of Ohio Marshes, after Riddell, 1835.

1390 Alisma plantago-aquatica L.
1738 Aspidium thelypteris (L.) Sw.
1000 Bidens lævis (L.) BSP. (B. chrysanthemoides Ell.).
68 Caltha palustris L.
106 Cardamine hirsuta L. (C. virginica).
11 Cicuta bulbifera L.
10 C. maculata L.
1127 Convolvulus sepium pubescens (Gray) Fernald. (C. repens L.).
1436 Cypripedium hirsutum Mill. (C. spectabile Swartz).
241 Decodon verticillatus (L.) Ell.
1161 Dodecatheon meadia L. (D. integrifolium Michx.).
1672 Dulicheum arundinaceum (L.) Britt. (D. spathaceum Pers.).
1677 Eleocharis intermedia (Muhl.) Schultes. (Scirpus intermedius Muhl.).
1674 E. palustris (L.) R. & S. (S. palustrus L.).
1678 E. tenuis (Willd.) Schultes. (S. tenuis Willd.).
1728 Equisetum fluviatile L. (E. limosum L.).
930 Eupatorium perfoliatum L.
1044 Galium tinctorium L. (G. obtusum Big.).
855 Gnaphalium uliginosum L.
734 Ilex verticillata (L.) Gray. (Prinos verticillatus L.).
1444* Juncus polycephalus Michx.
1658 Leersia oryzoides (L.) Sw.
770 Lobelia puberula Michx.
226 Ludwigia alternifolia L.
1448 Melanthium virginicum L.
1273 Mentha piperita L. (naturalized?).
98* Nasturtium amphibium Brown.
14 Oxypolis rigidior (L.) Coult. & Rose. (Archemora rigida DC.).
1223 Pedicularis lanceolata Michx. (P. pallida Pursh).
1140 Phlox maculata L.
703 Polygonum amphibium L.
699 P. hydropiperoides Michx. (P. mite Pers.).
97 Radicula palustris (L.) Moench. (Nasturtium palustre DC.).
56 Ranunculus abortivus L.
63 R. delphinifolius Torr. (R. lucustris Bk.).
971 Rudbeckia laciniata L.
724 Rumex verticillatus L.
1693 Rynchospora glomerata (L.) Vahl.
1391 Sagittaria latifolia Willd. (S. sagittifolia Willd.).

1392 S. latifolia obtusa (Muhl.) Robinson. (S. obtusa Willd.).
729 Saururus cernuus L.
183 Saxifraga pennsylvanica L.
1679 Scirpus validus Vahl. (S. lacustris L.).
950 Senecio aureus gracilis (Pursh) Britt. (S. gracilis Pursh).
12 Sium cicutæfolium Schrank. (Sium latifolium).
638* Stellaria longipes Goldie. (S. palustris Retz.).
1511 Typha angustifolia L.
1510 T. latifolia L.
1185 Veronica anagallis-aquatica L.
1186 V. scutellata L.
1400* Xyris caroliniana Walt.

Plants of Ohio "Prairies," after Riddell, 1835.

669* Acnida rusocarpa Michx. (Amarantus altissimus Ridd.).
670* Amaranthus miamiensis Ridd.
397 Amphicarpa monoica (L.) Ell. (A. comasa).
988 Coreopsis tripteris Willd.
520 Euphorbia dentata Michx. (E. herronii Ridd.).
1108 Gentiana villosa L. (G. ochroleuca Willd.).
1220 Gerardia auriculata Michx.
275 Geum canadense Jacq. (G. album).
1426 Habenaria psycodes (L.) Sw. (H. fissa Brown).
615* Hudsonia ericoides L.
1134 Ipomoea lacunosa L. (Convolvulus micranthus Ridd.).
1349 Onosmodium hispidissimum McK. (O. hispidum Michx.).
1313 Physostegia virginiana Benth. (Dracocephalum virginianum L.).
319 Prunus americana Marsh.
1285 Pycnanthemum flexuosum (Walt.) BSP. (P. linifolium Pursh).
286 Rosa setigera Michx. (R. rubifolia).
625 Silene regia Sims.
1008 Silphium perfoliatum L.
1006 S. trifoliatum L. (S. ternatum L.).
921 Solidago riddellii Frank.
912* S. stricta Ait.
1169 Steironema lanceolatum hybridum (Michx.) Gray. (Lysimachia hybrida Michx.).
1453* Stenanthium gramineum (Ker.) Kunth. (Veratrum angustifolium Pursh).
472 Strophostyles helvola (L.) Britt. (S. diversifolius).
1065 Viburnum prunifolium L.

Plants of Ohio Swamps, after Riddell, 1835.

1529 Acorus calamus L.
989 Bidens trichosperma (Michx.) Britt. (Coreopsis trichosperma Michx.).
1417 Calopogon pulchellus (Sw.) R. Br.
1711 Carex folliculata L.
1724 C. riparia Curt. (C. lacustris Willd.).
1127 Convolvulus sepium pubescens (Gray) Fernald. (C. repens L.).
1678 Eleocharis tenuis (Willd.) Schultes. (Scirpus tenuis Willd.).
1600 Glyceria canadensis (Michx.) Trin. (Poa canadensis Torr.).
1599* G. obtusa (Muhl.) Trin. (Poa obtusa Muhl.).
1193* Gratiola aurea Muhl.
1440 Juncus nodosus L.
1439* J. setaceus Rostk.
1389 Larix laricina (DuRoi) Koch (Pinus pendula Ait.).
1171 Lysimachia thyrsiflora L. (L. capitata Pursh).
1537 Muhlenbergia mexicana (L.) Trin. (Agrostis lateriflora Michx.).
589* Polygala brevifolia Nutt.
562 Rhus vernix L.
971 Rudbeckia laciniata L.
1692 Rynchospora alba (L.) Vahl.

1688 Scirpus lineatus Michx. (Tricophorum lineatum Pers.).
755 Vaccinium corymbosum L.
602 Viola striata Ait. (V. ochroleuca Schw.).

Plants of Ohio Wet Prairies, after Riddell, 1835.

856 Antennaria plantaginifolia (L.) Richards. (Gnaphaleum plantagineum L.).
1090 Asclepias incarnata L.
1089 A. incarnata L. (A. amoena Willd.).
1093* A. michauxii Dcne. (A. angustifolia Ell.).
1738 Aspidium thelypteris (L.) Sw.
869 Aster novæ-angliæ L.
880 A. puniceus L.
1000 Bidens lævis (L.) BSP. (B. chrysanthemoides Ell.).
989 B. trichosperma (Michx.) Britt. (Coreopsis trichosperma Michx.).
432 Boehmeria cylindrica (L.) Sw.
1617 Bromus purgans L.
940 Cacalia suaveolens L.
1417 Calopogon pulchellus (Sw.) R. Br.
767 Campanula aparinoides Pursh.
1709 Carex lurida Wahl. (C. tentaculata Muhl.).
1054 Cephalanthus occidentalis L.
1203 Chelone glabra L.
826 Cirsium muticum Michx. (Carduus glutinosus Bk.).
1078 Cornus paniculata L'Herit.
209 Epilobium densum Raf. (E. lineare).
208* E. palustre L.
8 Eryngium aquaticum L.
930 Eupatorium perfoliatum L.
297 Filipendula rubra (Hill) Robinson. (Spiræa lobata).
1044 Galium tinctorium L. (G. obtusum Big.).
1110 Gentiana crinita Froel. (G. crinata Willd.).
1107 Gentiana saponaria L.
1217 Gerardia purpurea L.
1199 Gratiola virginiana L. (G. virginica L.).
1425 Habenaria fimbriata (Ait.) R. Br.
170 Hypericum parviflorum Willd.
736* Ilex lanceolatus (Pursh) Chapm. (Prinos lanceolatus Pursh).
407 Lathyrus venosus Muhl.
1658 Leersia oryzoides (L.) Sw.
1502 Lilium canadense L.
773 Lobelia kalmii L.
769 L. siphilitica L.
772 L. spicata Lam. (L. claytoniana Michx.).
1448 Melanthium virginicum L.
1197 Mimulus alatus Ait.
1537 Muhlenbergia mexicana (L.) Trin. (Agrostis lateriflora Michx.).
1736 Onoclea sensibilis L.
14 Oxypolis rigidior (L.) Coult. & Rose. (Archemora rigida DC.).
193 Parnassia caroliniana Michx. (P. americana).
1223 Pedicularis lanceolata Michx. (P. pallida Pursh).
1517 Peltandra virginica (L.) Kunth. (Lecontia virginica Cooper).
1140 Phlox maculata L.
1314 Physostegia virginiana (L.) Benth. (Dracocephalum variegatum Vent.).
1595 Poa trivialis L. (naturalized?).
707 Polygonum sagittatum L.
493 Populus heterophylla L.
261 Potentilla fruticosa L.
796 Prenanthes racemosa Michx.
55 Ranunculus pennsylvanicus L.
1392 Sagittaria latifolia obtusa (Muhl.) Robinson. (S. obtusa Willd.).
481* Salix discolor Muhl. (S. coniferæ).
480 Salix petiolaris Smith. (S. rosmarinifolia).

256 Sanguisorba canadensis L.
1331 Scutellaria lateriflora L.
950 Senecio aureus gracilis (Pursh) Britt. (S. gracilis Pursh).
920 Solidago ohioensis Ridd.
1651 Sorghastrum nutans (L.) Nash. (Andropogon nutans L.).
1645 Spartina michauxiana Hitchc. (S. cynosuroides Willd.).
292* Spiræa salicifolia L.
1413 Spiranthes præcox (Walt.) Wats. & Coult. (S. tortilis Rich.).
1167 Steironema quadriflorum (Sims) Hitchc. (Lysimachia revoluta Nutt.).
1168 S. quadrifolia L. (L. quadrifolia Sims).
47* Thalictrum corynellum DC. (T. cornuti).
834 Vernonia fasciculata Michx. (V. corymbosa Schw.).
1186 Veronica scutellata L.
591 Viola affinis Le Conte.
1400* Xyris caroliniana Walt.
1655* Zizaniopsis miliacea (Michx.) Doll. & Asch. (Zizania miliacea Michx.).

The present known distribution within Ohio of every species in each list has been studied. Those marked with an asterisk are of course not at present recorded as found in the state. Of the remainder, a number are of general distribution within Ohio. Of those whose distribution is restricted, however, practically all are limited to those counties which are shown in Fig. 1 of this paper to have contained treeless areas of one sort or another.

No discussion of prairies in North America can be completed without mention of the thorough annotated bibliography of Shimek (18). To the papers cited there the reader is referred for many interesting accounts of the early grasslands. Moreover, in them may be followed the development of theory regarding the ecological significance of grasslands.

It has become somewhat common to speak patronizingly of early attempts to formulate an adequate theory. This is unjust. The first attempts, it must be remembered, preceded our knowledge of glacial physiography, meteorological data on a wide scale, rapid transit, photography, scientific plant geography, and physiology of water relations. One by one, as the current state of knowledge permitted, the locally limiting factors responsible for the absence of trees were perceived by the early naturalists until the whole formed a consistent unit. The broad outlines of this resultant conception have not been seriously modified by modern technical studies. Bourne's wise appraisal of the situation in Ohio, written in 1819 (19) and the judicious summary by Newberry in 1873 (20) deserve to be remembered.

SUMMARY AND CONCLUSIONS.

1. The foregoing paper attempts to locate and characterize all of the so-called "prairies" of Ohio which were a part of the native vegetation and of which any record has been found. These areas appear as prairies, wet prairies, dry prairies, bogs, oak openings, barrens, and swamps, all more or less associated.

2. These regions relate themselves obviously to physiography. In general they represent areas of inadequate drainage or actual ponding consequent upon glacial outwash near the apices of the various morainal lobes. Within the Erie Basin they mark the ancient shore lines. There seems to be a sufficiently close relation between preglacial topography and the position of the glacial moraines to bring a large proportion of the prairies within the silted valleys of preglacial drainage lines.

3. By use of nontechnical contemporary descriptions an attempt is made to reconstruct the physiognomy of the original prairies. Apart from bog meadows most of them were wet, displaying variously *Juncus*, *Scirpus*, *Typha*, *Phragmites*, *Spartina*, *Calamagrostis* and *Andropogon furcatus*, as well as numerous dicotyledonous herbs. Sometimes elm, ash, willow were conspicuous invaders. In other cases there was a dryer herbaceous border dominated by *Andropogon scoparius* with various composites, etc. Between this and the oak-covered uplands was frequently a shrub zone of plum, hazel, and wild rose. Still higher were open groves of oak and hickory.

4. A floristic reconstruction of the various types of prairie has been made upon the basis of Riddell's Early Western Flora.

LIST OF REFERENCES CITED.

1. Waller, A. E.
The relation of plant succession to crop production. Ohio State Univ. Bull. 25, 9: 1–74. 1921.

2. Sears, P. B.
The natural vegetation of Ohio. I. A map of the virgin forest. Ohio Journ. of Science 25: 139–149. 1925.

3. Dachnowski, A.
Peat deposits. Geol. Surv. of Ohio. 4 ser. Bull. 16: 1–424, 1912.

4. Orton, E. L.
Report of the Geology of Madison County. Geol. Survey of Ohio, Geol. 3: 423–424. 1878.

5. Gilbert, G. K.
(Work of) (Referred to by J. S. Newberry in) Geol. Survey of Ohio, Geol. 2: 50–65. 1874.

6. Winchell, N. H.
(a) Report on the Geology of Wood County, Geol. Survey of Ohio. Geol. 2: 368. 1874. (b) Report on the Geology of Van Wert County. Ibid. 314. 1874.

7. Read, M. C.
(In) Geol. Survey of Ohio, Geol. 3: 529. 1878.

8. Tight, W. G., Bownocker, J. A., Todd, J. H., and Fowke, G.
The preglacial drainage of Ohio. Ohio Acad. Aci. Special Papers 3: 1–75. 1900.

9. Clark, W. B.
Drainage modifications in Knox, Licking, and Coshocton Counties. Bull. Sci. Lab. Denison Univ. 12, 1: 1–16. 1902.

10. Tight, W. G.
Drainage modifications in southeastern Ohio, and adjacent parts of West Virginia and Kentucky, U. S. G. S. Prof. Paper 13: 1–111. 1903.

11. Anonymous.
Observations on the flora of the western states. Cincinnatus, 1: 209. 1857.

12. Gist, C.
Quoted in Williams, B. History of Clermont and Brown Counties, Milford, O., 1913.

13. Pease, S.
Survey of the 8th Meridian, MS notes of Western Reserve Survey 2, 2. 1796.

14. Bradley, C. P.
Journal of Cyrus P. Bradley, 1835. Ohio Arch. Hist. Soc. Pubs. 15: 234. 1906.

15. History of Madison County, O., W. H. Beers & Co., Chicago, 1883.

16. Riddell, J. L.
A synopsis of the flora of the western states. 1–116. Cincinnati. 1835.

17. Schaffner, J. H.
Catalog of Ohio Vascular Plants. Ohio Biol. Survey 1, 2: 127–247. 1914. For supplements see files of Ohio Journal of Science (Ohio Naturalist) since 1915.

18. Shimek, B.
The Prairies. Bull. Lab. Nat. Hist. Uni. of Iowa 6: 169. 1911.

19. Bourne, A.
On the prairies and barrens of the west. Am. Journ. Sci. & Arts. 1 ser. 2: 30–34. 1820.

20. Newberry, J. S.
Physical Geography of Ohio. Geol. Surv. Ohio, Geol. 1: 16–49. 1873.

NOTES ON THE DEVELOPMENT OF THE GAMETOPHYTE AND EMBRYO OF ASPLENIUM ANGUSTIFOLIUM MICHX.

RUSKIN S. FREER,
Lynchburg College.

OCCURRENCE.

Asplenium angustifolium Michx., (*Asplenium pycnocarpon* Spreng.), the Narrow-Leaved Spleenwort, may be found from western Quebec and New Hampshire to Minnesota, and southwards to Georgia, Alabama, Missouri and Kansas (Gray, 24, and Britton and Brown, 6). Eaton (12) states that it probably occurs in the mountains of northern Georgia, and that it is more common in the Ohio valley than in New England. He also states that it has no close relatives anywhere, the nearest being a South African species, *Asplenium anisophyllum.*

There are two records of its occurrence in Louisiana, (Pennell, 21), and it is listed in Mohr's "Plant Life of Alabama," from a mountain region with an elevation of fifteen hundred feet. The Louisiana station is at an elevation of less than two hundred feet. Otherwise its southern distribution seems to be montane.

Asplenium angustifolium is reported as occurring very abundantly in some places in Camden County, Missouri, especially in limestone sinks, where it may cover an acre or more, to the exclusion of other vegetation (Standley, 26). It is generally spoken of as one of the rarer ferns by New England students of the pteridophytes, but when found, is frequently reported as growing closely associated with Goldie's Fern, *A. Goldianum* (5, 11, 16).

Of interest in connection with the occurrence of *A. angustifolium* is the following note by A. H. Young (41) from the first issue of the Botanical Gazette, then called the Botanical Bulletin, published in November, 1875:

"*A. angustifolium* * * * is found in southern Indiana. It is an inhabitant of cooler regions, and here it seeks the coolest and dampest portions of the ravines running back from the Ohio river, and it is always found encircled by a rich carpet of moss to shield its roots from the heat and retain sufficient

moisture. It is by no means abundant, and indeed this remark will apply to all our ferns with the exception of three or four species."

A survey of Ohio botanical literature indicates that the Narrow-Leaved Spleenwort is not a common plant. There are specimens in the herbarium at the Ohio State University from twenty counties, not including Delaware County. Griggs (18) includes it in his list of plants of the Sugar Grove region. Moseley (19) speaks of it as infrequent in Erie County. Schaffner (25) lists it as general, but not common in the state.

The single plant from which spores for this work were obtained, was found in a shaded ravine on the east side of the Scioto River Valley, about four miles west of Delaware, Ohio.

A. angustifolium is usually found in ravines in rich soil, where shade and moisture are abundant. One writer (33) states that it prefers a basic soil, but tests of the soil around the plant used in this work showed results to the contrary.

The stipes grow in tufts, are very erect, and are from one to four feet in length. The leaves are pinnate, with numerous pinnæ, which are linear-lanceolate, acuminate, with entire margins. The fertile fronds are narrower than the sterile. The fruit dots are linear. The fronds are very thin and are easily affected by frost. Woolson, as quoted by Tilton (32), writes of it, "There is nothing in the fern kingdom which looks so cool and refreshing on a hot day as a mass of this clear-cut, delicately made-up fern."

WORK ON RELATED GENERA.

So far as the writer has been able to discover, no work has been done on the gametophyte of *A. angustifolium*, and except for the work of Campbell (9) and Pickett (23), very little has been done on the complete development of the gametophyte of any of the Polypodiaceæ. The former has described the development of *Onoclea Struthiopteris*, and the latter more recently has worked out the development of the prothallium of *Camptosorus rhizophyllus*.

Much has been done, however, in the study of certain phases of the development of the gametophyte of the Polypodiaceæ. Atkinson (2) was the first worker to report polyembryony in the ferns. He found this condition in *Adiantum cuneatum*. Recently Etter (13) has successfully determined

methods for bringing about polyembryony in *Matteucia Struthiopteris*, *Dryopteris mollis*, *Onoclea sensibilis*, and *Pteris longifolia*.

Farlow's (14) discovery of an asexually developed sporophyte on *Pteris cretica* var. *alba lineata* in 1874, was the beginning of numerous studies in apogamy.* Steil (27) has described apogamy in *Pellea atropurpurea*, and (28) in *Notholaena*, *Pteris* and *Aspidium*. Miss Wuist (38, 8) had similar results with *Phegopteris polypodioides* and *Camptosorus rhizophyllus*. Yamanouchi (39, 40) has done a very excellent piece of work on *Nephrodium*, in the study of apogamy, spermatogenesis, oogenesis and fertilization.

Miss Ferguson (15), without knowing of Miss Black's (3) work on imbedded sexual cells in *Dryopteris stipularis* and *Nephrodium molle*, found similar structures in some species of Pteris. Miss Black's paper, which was published first, raises some very interesting questions as to sex inheritance, and the influence of environmental factors, particularly direct sunlight and dryness, on determination of sex. She also raises some question as to the validity of Yamanouchi's assumption that the embryo shown in Plate 10, Figure 29, (40) developed in an apogamous manner from the shaded cell in his Figure 1.

Goebel (17)* has given an account of apospory in *Asplenium bulbiferum*, and Steil (29, 30) has reported this condition in *Pteris sulcata* and *Polypodium irioides*.

Miss Wuist (35, 36) and Mottier (20) have studied the environmental factors controlling sex in the prothallia of *Onoclea Struthiopteris*. A reference is made to their work later.

Miss Black (4) has reported branched cells in the prothallia of *Onoclea sensibilis*, and Miss Wuist (37) records many genera and species of the Polypodiaceæ in which branched prothallia occur. The branched cells reported by Miss Black were developed under water. A deficient oxygen supply was believed to be the cause of this abnormality. Miss Wuist's results were attributed to nutrition.

Several other unrelated papers have been published, bearing on some phase of the development of the gametophyte of the Polypodiaceæ. Some interesting observations on unequal segmentation in the embryo of *Adiantum cuneatum* and *Pteris serrulata* have been made by Atkinson (1). Woodburn (34) found an instance of polyspermy in *Onoclea Struthiopteris*.

*The writer was unable to secure the original papers.

Four neck canal cells with a definite wall between two of the neck canal cell nuclei, were found by Miss Pfeiffer (22) in *Pteris longifolia*. Successful attempts at regeneration from young detached sporophyte leaves of *Phegopteris polypodioides* were made by Mrs. Brown (7). The leaves were placed in sand moistened with nutrient solutions. One produced a prothallus-like structure which in turn produced four new sporophyte leaves. Vegetative reproduction, and development of prothallia and secondary antheridia from both antheridia and archegonia, have been observed by Steil (30, 31) in *Polypodium irioides*. He assigns unusual cultural conditions as the cause.

THE SPORE AND ITS GERMINATION.

Before germination the spores are enclosed in a roughly and irregularly wrinkled perinium (Text-Fig. 1, A). They are spherical and are about 50 micra in diameter. Germination begins with the swelling of the endospore and rupturing of the perinium, followed by the extension of the first rhizoid, which makes rapid growth (Text-Fig. 1, A, B, C). Chloroplasts are numerous in the swollen endospore, though not so densely crowded together as in older cells. The chloroplasts are oval in shape. The perinium adheres to the first cell for a long time, being present usually on gametophytes bearing fertilized egg cells.

Spores were sown on soil in earthenware platters. These platters of soil had been thoroughly sterilized in an autoclave. In addition to the sowings on soil, others were made on Knop's solution and on sphagnum. The platters were covered with battery jars in such a manner as to allow ventilation, and were kept in the greenhouse at a temperature of about 70° and subjected to the usual greenhouse lighting conditions. At least a month was required for germination in some cases, and growth was slow. In one case, small prothallia were visible with the aid of a pocket lens in thirteen days after sowing, and were visible to the unaided eye in twenty-four days. Cultures of *Pteris longifolia* sown at the same time germinated more rapidly and made a great deal more rapid growth all along. Other experimenters report germination and greening of the soil in from three to seven days for the species more commonly studied, but Pickett (23) states that a period of twenty-five days elapsed between the sowing and first appearance of green in the case of *Camptosorus rhizophyllus*. The gametophytes of *Asplenium*

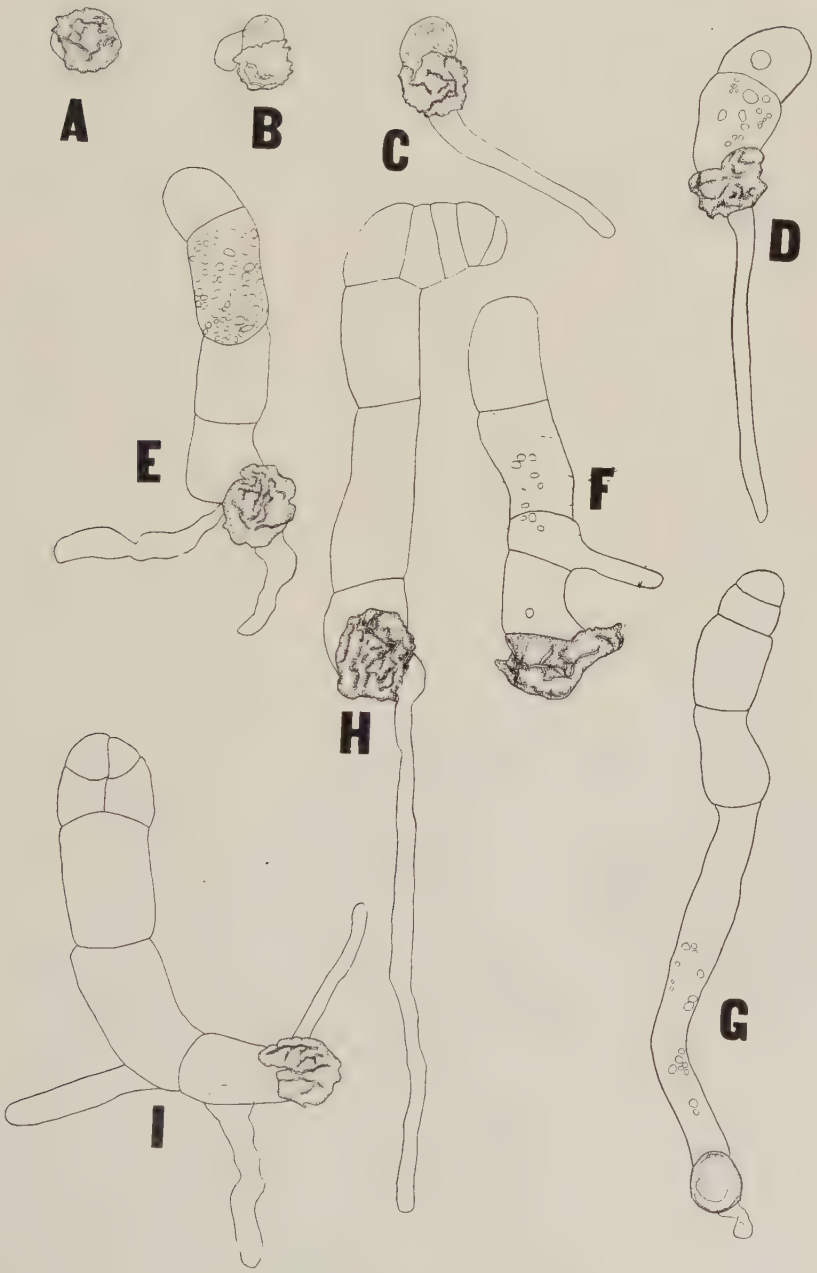

Fig. 1. Germination of spore, and early divisions of prothallium, A-E, and I. F, G, H, some unusual forms of the young prothallium. ×130.

angustifolium were easily affected by a change of environment, as was shown by transference to the laboratory, which was heated by a gas stove. Growth was greatly retarded. The prothallia grew poorly on sphagnum. Most rapid growth took place on sterilized soil, while germination and growth on Knop's solution were somewhat slower. Judging from the slow growth they made, optimum conditions apparently were not obtained with most of the cultures.

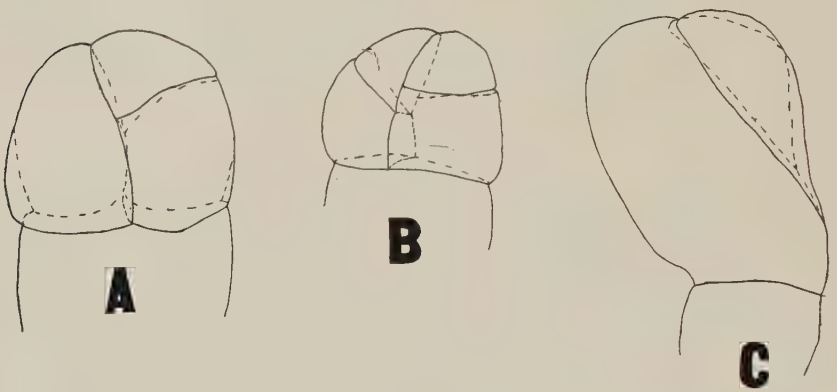

Fig. 2. Methods of division in terminal cell. ×170. *x*, apical cell.

DEVELOPMENT OF PROTHALLIA.

Further growth proceeds by division in a single plane for a time, (Text-Fig. 1, D, E, F, G), resulting in a protonema or filament, containing as many as nine cells (Text-Fig. 3, D), although division in a second plane may occur after the formation of only four cells, as shown in Text-Figure 3, B. An unusual elongation of the first cell is shown in Text-Figure 1, G. The perinium which is usually retained for some time, was not present on this filament. An irregular growth in which one or more cells were developed on the side of the young gametophyte is represented in Text-Figure 3, C. There were only a few such cases, all found growing on Knop's solution. Another peculiar behavior was frequently observed in prothallia grown on Knop's solution. After the development of a filament a few cells long, further growth was at right angles to the older cells, (Text-Figure 1, H). Probably this was caused by changing the position of the glass vessel with respect to the light. The prothallia grew prostrate on the solution. These growths closely resemble Figure 5 of Plate 22, illustrating Miss Black's paper (4) on branched cells.

Division in a second plane in the normal terminal cell takes place after six or eight transverse divisions. This division frequently occurs simultaneously in the last two cells formed

Fig. 3. Young filamentous prothallia. ×145. *x*, apical cell.

(Text-Figs. 1, I; 3, A). This is quite different from the usual behavior of *Onoclea Struthiopteris*, as recorded by Campbell (9), in which the first longitudinal division is oblique, and takes place

only in the terminal cell of the filament. Ordinarily, however, *Asplenium angustifolium* conforms to the method of division illustrated in Text-figures 2, A, B; 3, B. Here the terminal cell divides by formation of a longitudinal wall (Text-Fig. 2, A).

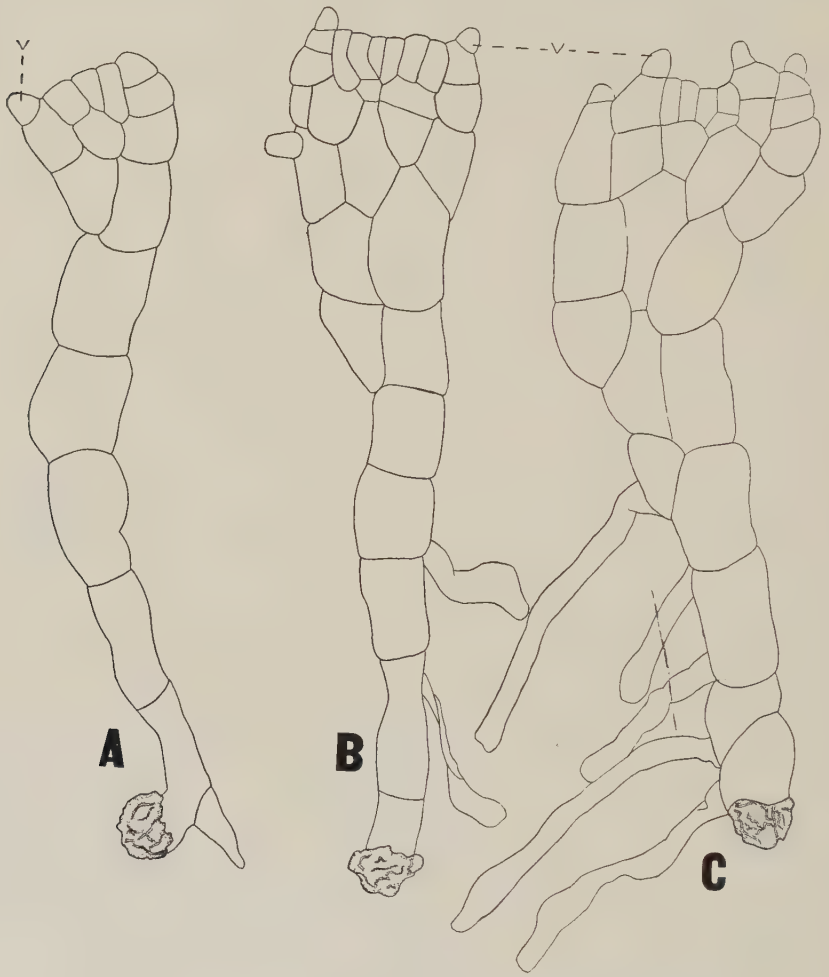

Fig. 4. Young gametophytes. ×145. *v*, young glandular hairs.

A somewhat oblique wall is next formed, resulting in the apical cell (*x*, Text-Fig. 2, A). The next is a transverse wall (Text-Fig. 2, B), then another longitudinal wall divides the large cell immediately below the former terminal cell (Text-Fig. 3, B). Only one case resembling the method Campbell described for *O. Struthiopteris* was observed (Text-Fig. 2, C).

The apical cell (*x*, Text-Figs. 2, A, B; 3, B) is the center of growth during the subsequent development of the gameto-

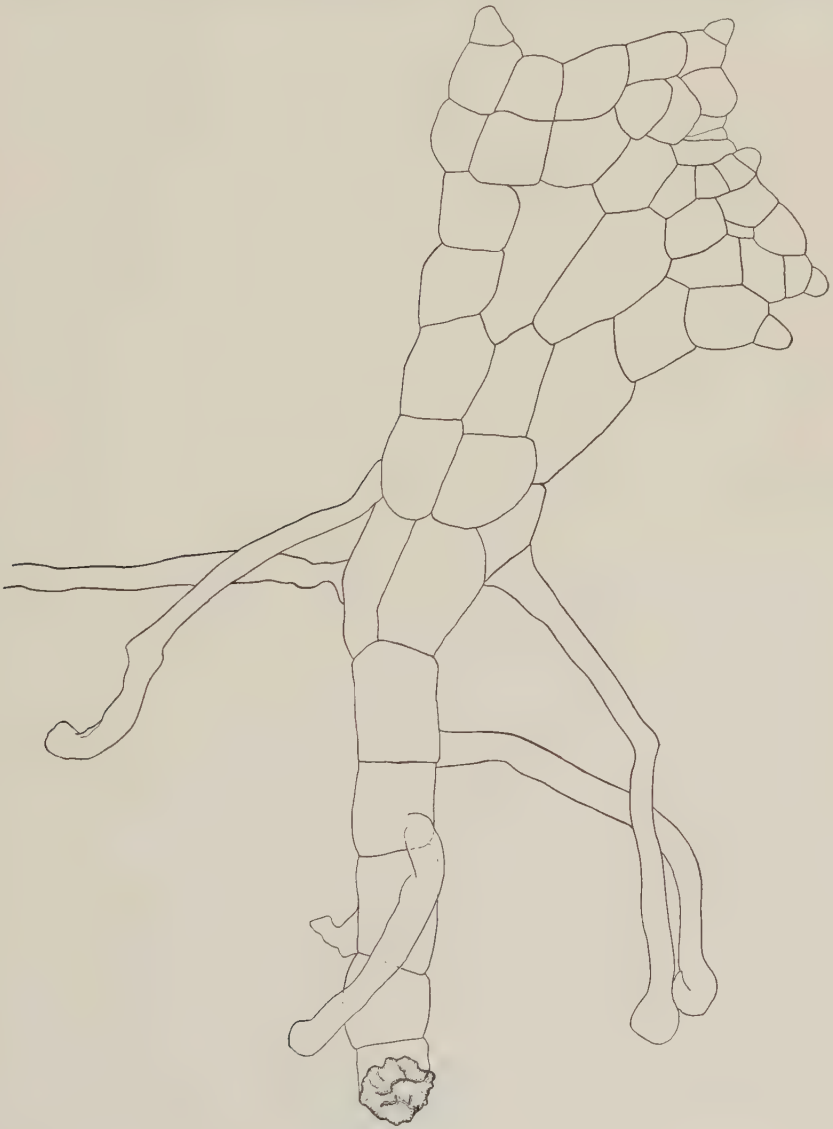

Fig. 5. Young fan-shaped gametophyte. ×150.

phyte. It is sometimes difficult to point out the apical cell in the earlier stages, but it may usually be distinguished by its triangular shape.

Mitotic figures have been observed frequently by the writer in the cells of the archegonial cushion, and not at all in the cells

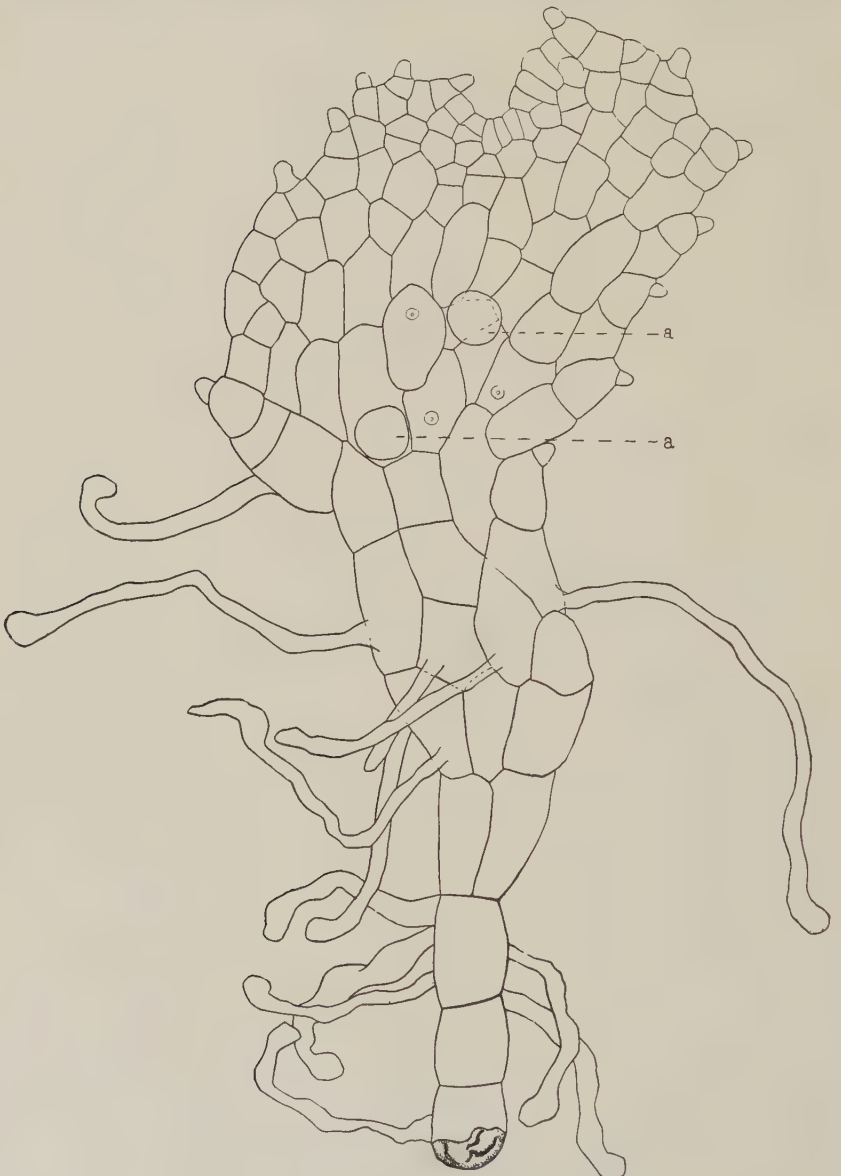

Fig. 6. Young gametophyte bearing two antheridia, *a*. ×100

of the surrounding lobes. They occur only in the anterior part of the cushion, however, (Text-Fig. 9, C). But it is

evident that cell division takes place not only in the apical cells, but in adjacent cells as well.

A rapid widening of the upper part of the prothallium follows the appearance of the apical cell, a fan shape being

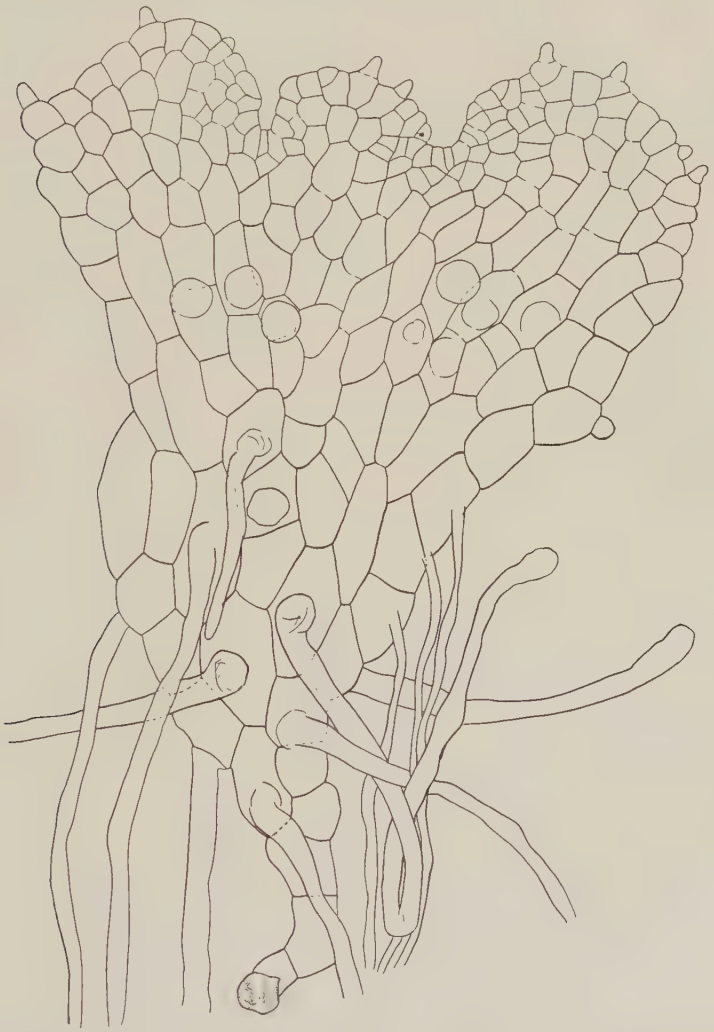

Fig. 7. Young prothallium showing two apical sinuses and several antheridia. ×105.

assumed, (Text-Figs. 3, D; 4, A, B, C; 5). By the rapid cutting off of cells on either side of the apical cell, lobes are developed, resulting in an apical sinus or indentation, which becomes deeper as the prothallium matures (Text-Figs. 6, 7).

This process results eventually in the regular heart-shaped structure which characterizes most fern prothallia.

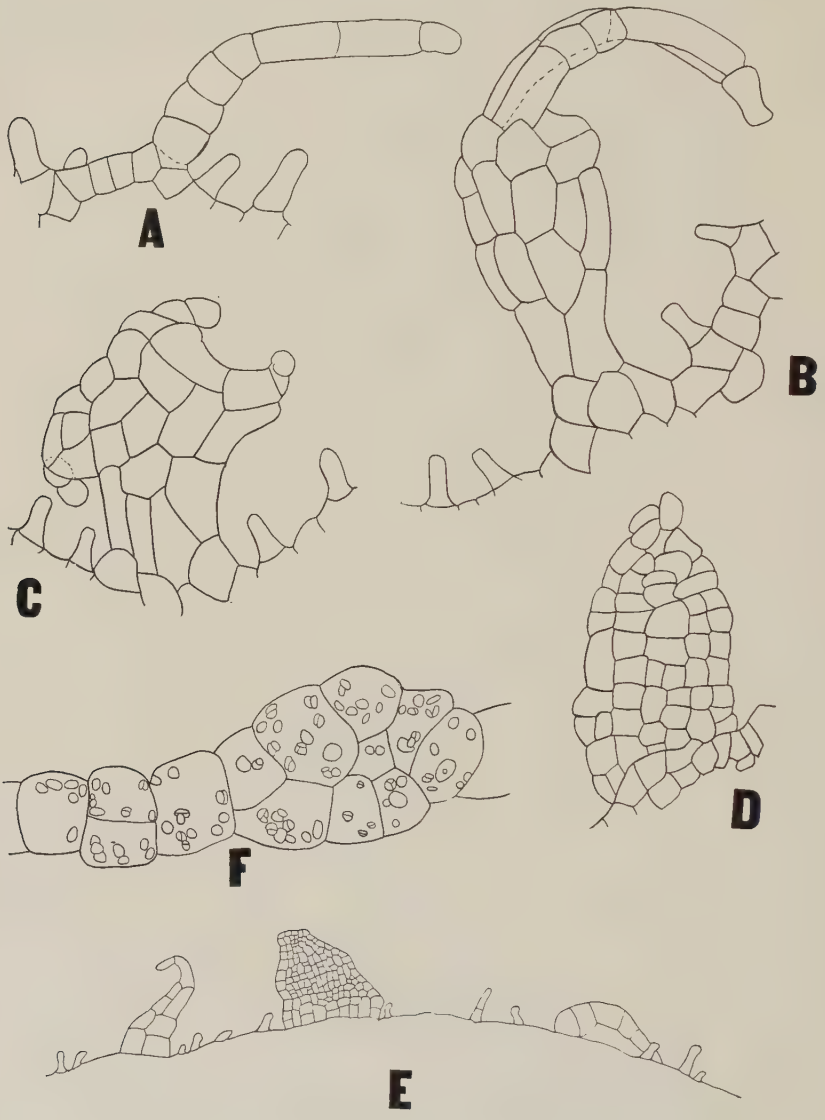

Fig. 8. Proliferations found on prothallia of *A. angustifolium*. A, B, C, D, F, ×125; E, ×50.

Very soon after the apical cell is discernible certain peculiar vegetative cells appear (*v*, Text-Fig. 4, A, B, C), which persist throughout the life of the gametophyte. Steil (28) designates

such structures as glandular hairs, and states that they occur in all species of *Aspidium* in which apogamy has been found, but that they do not occur in *Pellea* or *Pteris*.

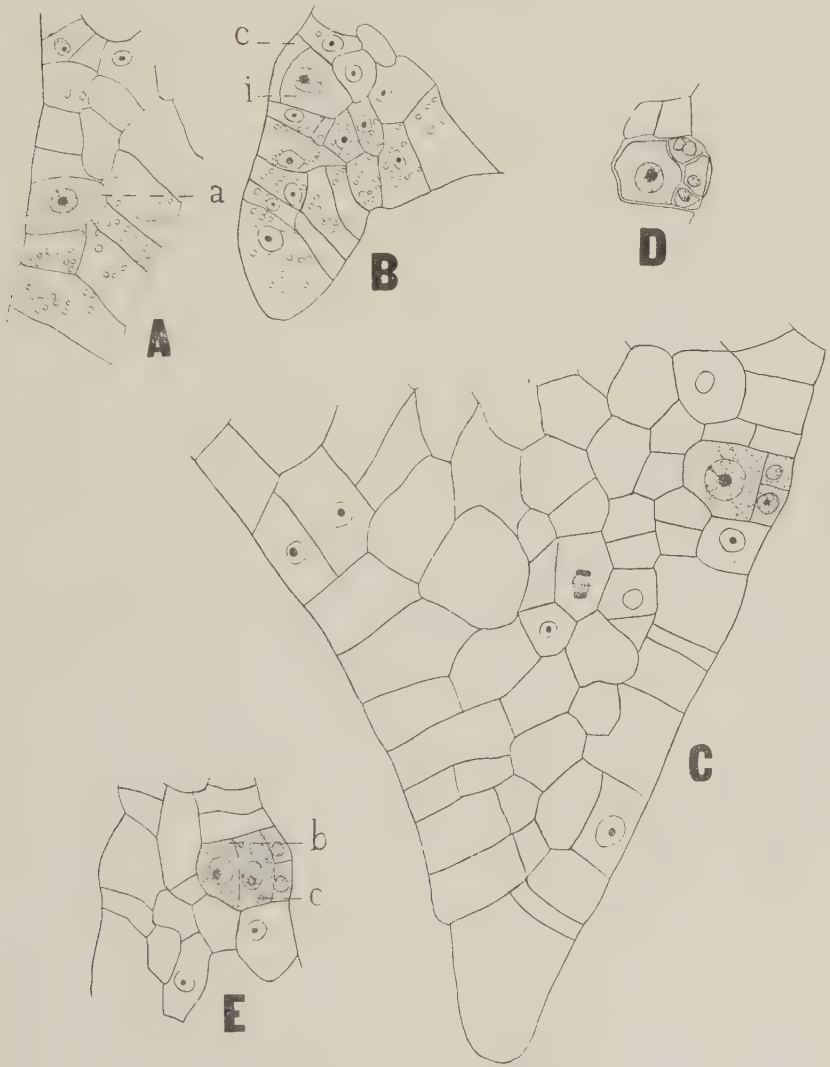

Fig. 9. A. *a*, archegonium initial. B. *c*, cap cell; *i*, inner cell. C. First division of cap cell. D. Second division of cap cell. E. First division of inner cell; *b*, basal cell; *c*, central cell. ×240.

The prothallium remains only one cell in thickness until it is about 2 mm. across, before the midrib or archegonial cushion is developed around the apical sinus. This is accomplished by

the cutting off of posterior segments from the apical cell or cells. These posterior segments then divide in a plane parallel to that of the prothallium, forming a cushion two cells thick. The older cushions are several cells thick, after many more posterior segments have been cut off from the apical cells, and after more divisions in the plane of the prothallium have occurred.

Pickett (23) finds irregularity of shape to be the usual thing in *Camptosorus rhizophyllus*. In *Asplenium angustifolium* the prothallia are remarkably regular in outline. However, a few prothallia showed unusual growths or proliferations along the wings. These outgrowths were devoid of chlorophyll, and took various forms (Text-Fig. 8, A-E). Several cases were found where there were two apical sinuses (Text-Fig. 7). Another interesting irregularity was discovered in one of the prothallia which was sectioned (Text-Fig. 8, F). Preceding and succeeding sections showed this to be a spherical cluster of cells out near the edge of the prothallium. It was entirely surrounded by only a single layer of normal cells. The cells comprising the cluster stained like the rest of the vegetative tissue, hence it was evidently simply a vegetative abnormality or proliferation.

THE DEVELOPMENT OF THE ARCHEGONIUM.

In the selection of prothallia for the study of archegonia, individuals were selected which seemed to be in the desired stage of development, and were examined under the microscope. In this way the particular age of the archegonium sought for may be determined fairly accurately. The wings of each prothallium selected were clipped off almost to the cushion, to reduce to a minimum the number of worthless sections on the slide.

After careful washing in distilled water, the prothallia were placed in chromo-acetic acid containing one minim of a 2% osmic acid solution per 100 c. c., for 12–36 hours. They were then washed in running water for 24 hours, and were run through the usual series of alcohols and alcohol-chloroform mixtures. Some dry erythrosin was added to the 100% alcohol to render the tiny pieces visible in the paraffin. The material was then imbedded in the usual way.

Sections were cut 5 micra thick and stained with the anilin-safranin, gentian-violet, orange G combination. The last dye was used in clove oil. Sections were examined with an oil immersion lens and drawings were made with the aid of a camera lucida.

Archegonia appear on the cushion on the ventral side of the prothallia when they are about 2 mm. across. The initial cell may be easily distinguished by its dense cytoplasm, very large nucleus, and keystone shape (Text-Fig. 9, A). After one becomes familiar with them, they may be found readily on most prothallia of the right age.

The first division of the initial cell results in the formation of the cap cell and the inner cell. The cap cell is thin in comparison with the latter (Text-Fig. 9, B). The nucleus of the

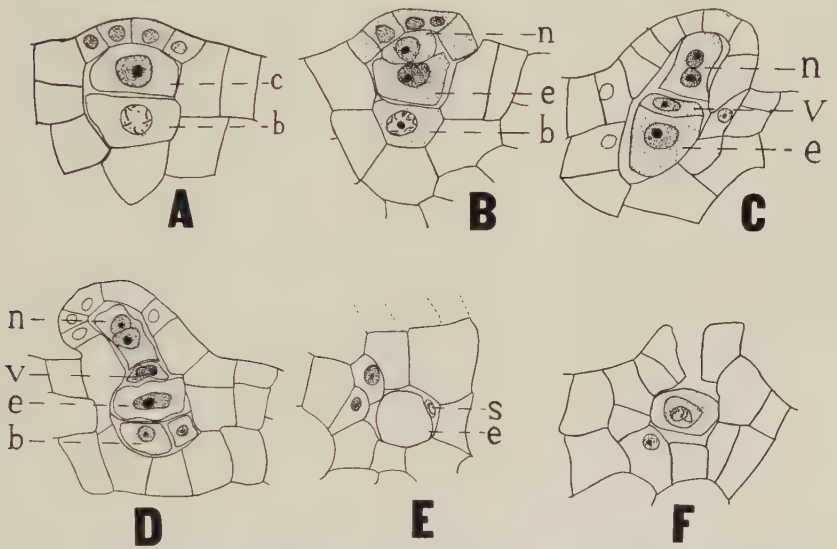

Fig. 10. Stages in the development of the archegonium. A. *c*, central cell; *b*, basal cell. B. *n*, cell which gives rise to neck canal cell; *e*, cell which gives rise to egg and ventral canal cell; *b*, basal cell. C. *n*, neck canal cell; *v*, ventral canal cell; *e*, egg. D. *n*, neck canal cell; *v*, ventral canal cell; *e*, egg; *b*, basal cells. E. *e*, egg; *s*, sperm. F. Fertilized egg, sperm within egg nucleus. ×230.

inner cell is larger than that of the first cap cell or its daughter cells. The first division of the cap cell is soon followed by divisions in the two daughter cells. These divisions which are at right angles to the first, result in the formation of the four cells constituting the chimney foundation (Text-Fig. 9, D). The inner cell divides into a basal and a central cell (Text-Fig. 9, E). The sequence of these divisions varies somewhat, but usually the second division of the cap cell precedes the first division of the inner cell. Text-Figure 10, A, B, representing mitotic stages in the basal cells, shows that the order of division may

vary also in the basal and central cells. In subsequent divisions the basal cell gives rise to the four cells (Text-Fig. 10, D) which form part of the wall of the venter. The central cell divides to form the neck canal cell, and a cell which gives rise to the egg and the ventral canal cell (Text-Fig. 10, B). The neck canal cell nucleus divides, forming two nuclei without a corresponding division of the cell, as shown in Text-Fig. 10, C, D. The arrangement of archegonial contents usually observed is best shown in C of this Figure. The basal cells, which are left out in C because of oblique sectioning, stained darkly in the section represented in D, just as they did in sections of younger archegonia (Text-Fig. 10, A, B). The last named divisions, accompanied by the development of the archegonial neck from the four cells of the chimney foundation, complete the growth of the archegonium. When mature, the necks of the archegonia are bent backwards toward the rhizoids, as is usually the case in the Polypodiaceæ. The degeneration of the neck canal and ventral canal cells gives rise to a gelatinous substance, which swells on absorption of water, and bursts open the lid cells of the archegonium. The gelatinous substance emerges, and forms a frothy mass at the opening of the neck. In this condition fertilization takes place.

SEX IN ASPLENIUM ANGUSTIFOLIUM.

Antheridia occur on the prothallia when the latter are quite young, and sometimes persist until archegonia appear, although usually the plant seems to be dioecious. No attempt was made to develop purely monoecious or dioecious plants by controlling environmental factors, but in one culture grown on an unusually concentrated Knop's solution, it was noted that antheridia were developed much earlier than in cultures grown upon sterilized soil. Archegonia were not found in the solution cultures.

Experiments having to do with the control of sex in ferns have been carried out on *Onoclea Struthiopteris* by Miss Wuist (36), Mottier (20), and others. Mottier believes that it is highly probable that the sex tendency is predetermined in the spore, and that the male tendency is dominant under good cultural conditions, but that the development of sex organs may be influenced by varying environmental conditions. This seems to be the case in *A. angustifolium*. In thickly sown cultures, antheridia are borne abundantly on the irregularly shaped prothallia as well as on those possessing the more typical

heart shape. The crowded condition prevents the maturing of the prothallia and proves but little about sex, other than that the young prothallia are largely male.

DEVELOPMENT OF ANTHERIDIUM.

The development of the antheridium in *A. angustifolium* is entirely normal, beginning with the cutting off of a single hemispherical initial on a surface or marginal cell of the prothallium (Text-Fig. 11, A, G). The first division of the initial

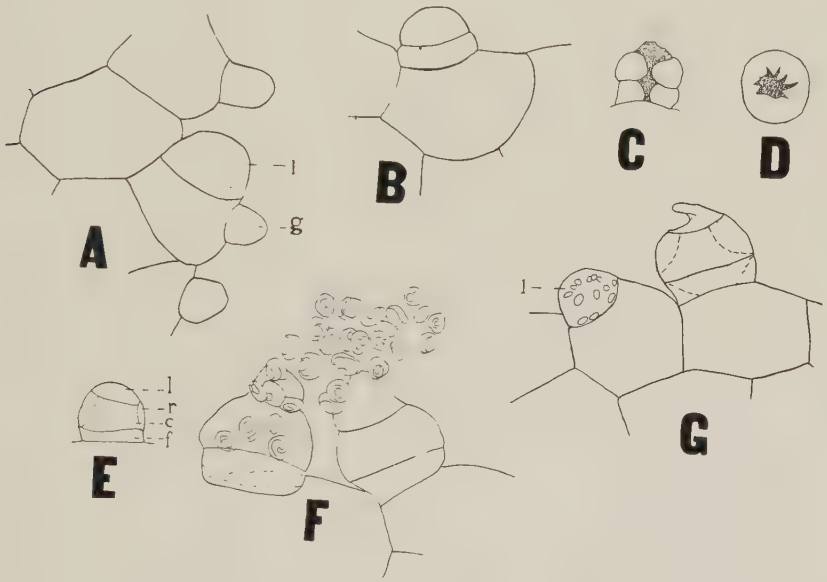

Fig. 11. Stages in development of antheridium. A. *i*, initial cell; *g*, young glandular hairs. B. Two-celled stage. C. Antheridium after escape of sperms, side view. D. Same, top view. E. Mature antheridium; *l*, lid cell; *r*, ring cell; *c*, central cell; *f*, funnel cell. F. Mature antheridia, sperms escaping from one at left. G. *i*, initial cell containing chloroplasts, with old antheridium. A, B, F, G, ×255. C, D, E, ×145.

results in the formation of a lower funnel cell and a dome-shaped upper cell (Text-Fig. 11, B). A periclinal division in the dome-shaped cell gives rise to the central cell and an arching cover cell (Text-Fig. 11, E). A final division of the cover cell results in the cap cell and the ring cell (Text-Fig. 11, G). The formation of the cap and ring cells completes the development of the antheridium. The central cell divides several times, giving rise to the sperm mother cells, from which the sperms or antherozoids are developed. Details of this development are beyond the scope of this paper.

Mature sperms are induced to escape from the antheridium by allowing the culture to become rather dry, and then transferring some of the antheridial prothallia to a drop of water on a slide. The rupture of the cap cell, swelling of funnel and ring cells, from water absorption, and consequent expulsion of the sperms, were observed under the microscope (Text-Fig. 11, F). After remaining tightly coiled at the opening of the antheridium for a few seconds, the sperms suddenly uncoil and immediately swim away by means of numerous cilia. Under laboratory

Fig. 12. A mature sperm. ×1465.

conditions locomotion may be kept up for about half an hour. Views of antheridia from which sperms have escaped are shown in Text-Figure 11, C, D, and G. A single mature sperm is represented in Text-Figure 12.

FERTILIZATION.

Several sections prepared for study of fertilization showed great numbers of sperms around the neck of the archegonium. Text-Figure 10, E, shows a sperm within the venter next to the egg, and fertilization is shown in F of the same figure. In this

case, the sperm was distinguishable in the egg nucleus, but no traces of cytoplasm were left on the outside of the egg. The most of the cells of the neck of the archegonium were missing in this section.

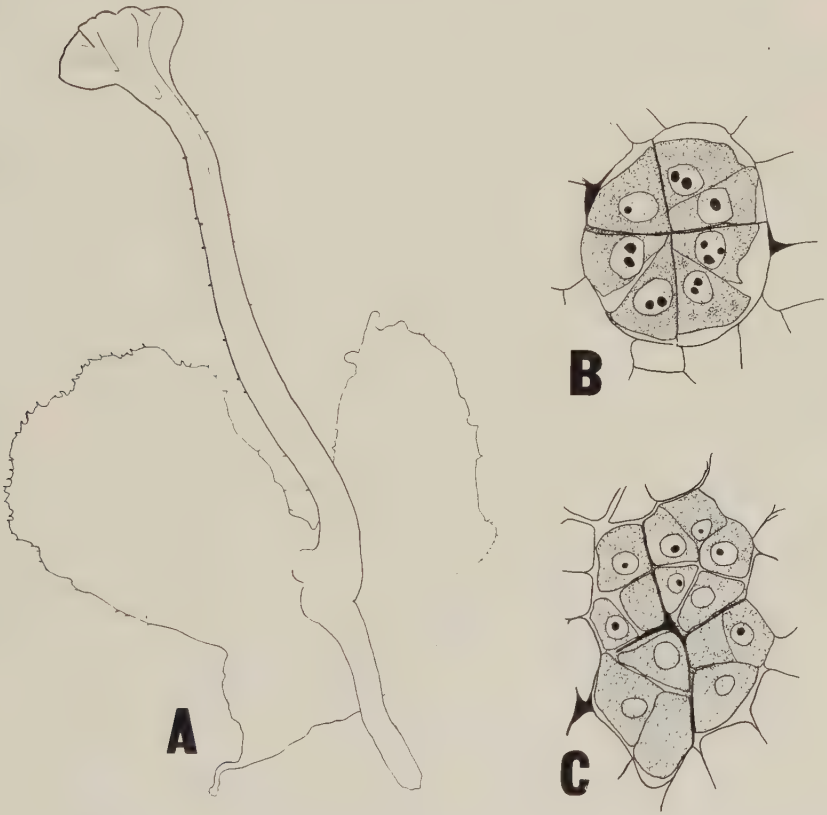

Fig. 13. A. Young sporophyte, ×9.5. B, C. Sections of young embryos, ×255.

In the material prepared for the study of the embryo, no sections contained the first division of the egg after fertilization, but several contained young embryos. Text-Figure 13, B, shows the youngest stage found, while C of the same figure represents one somewhat older. The quadrants, from which are developed the leaf, stem, foot and root of the young sporophyte, showed up very distinctly in the embryo sections. These four parts may be readily identified in Text-Figure 13, A.

SUMMARY.

1. The spores of *Asplenium angustifolium* germinate slowly. About a month is ordinarily required, although in one case small green prothallia were observed in thirteen days with the aid of a pocket lens. The fact of its slow germination, coupled with its scarcity and fragility, may be factors in a losing fight for survival of this species.

2. The steps leading to the formation of the apical cell differ from the method usually described for polypodiaceous ferns. The first division of the terminal cell is longitudinal instead of oblique, and both of the resulting cells divide transversely.

3. The protonemal filament is usually only three or four cells long when the terminal cell divides, but in some cases it is a great deal longer.

4. The perinium usually adheres throughout the life of the gametophyte.

5. The gametophyte is regularly heart-shaped. A few cases were observed where proliferations devoid of chlorophyll were developed around the edge of the prothallium. One proliferation took the form of a localized thickening of the wing.

6. The development of the archegonium conformed to the method usually described with the following exceptions: (a) The first division of the inner cell sometimes precedes and sometimes follows the formation of the chimney foundation from the cap cells. (b) The division of the central cell may precede or may follow the division of the basal cell.

7. In the development of the antheridium and the embryo, the stages usually described for ferns of this group are followed.

The writer wishes to express his great appreciation and gratitude to Professor C. E. O'Neal, of Ohio Wesleyan University, for his helpful suggestions and criticisms in the carrying on of this work.

LITERATURE CITED.

1. Atkinson, Geo. F.
   Unequal segmentation and its significance in the primary division of the embryo of ferns. Bull. Torr. Bot. Club 20: 405–407. 1898.
2. * * * Two perfectly developed embryos on a single prothallium of *Adiantum cuneatum*. Bull. Torr. Bot. Club 20: 407–408. 1898.
3. Black, Caroline A.
   The development of the imbedded antheridium in *Dryopteris stipularis* and "*Nephrodium molle*." Bull. Torr. Bot. Club 36: 557–571. Pls. 26–28, 1909.
4. * * * Branched cells in the prothallia of *Onoclea sensibilis*. Bull. Torr. Bot. Club 41: 617–620. Pls. 22, 23. 1914.
5. Blake, Sidney F.
   Notes on the ferns of the Champlain Valley. Am. Fern Jour. 4:115–119. 1914.
6. Britton, N. L., and Brown, A.
   Illustrated flora of northern United States and Canada. New York. 1913.
7. Brown, Elizabeth Dorothy Wuist.
   Regeneration in *Phegopteris polypodioides*. Bull. Torr. Bot. Club 45: 391–397. Figs. 1–3, 1918.
8. * * * Apogamy in *Camptosorus rhizophyllus*. Bull. Torr. Bot. Club 46: 27–30. Pl. II. 1919.
9. Campbell, D. H.
   The development of the Ostrich Fern. Memoirs of the Bost. Soc. Nat. Hist. Vol. 4, No. 2. pp. 17–52. Pls. 1–4. 1887. Review in Botanical Gazette 12: 302–303. 1887.
10. * * * The structure and development of mosses and ferns. New York. 1905.
11. Churchill, J. R.
    Brief note. Rhodora 7: 100. 1905.
12. Eaton, D. C.
    Ferns of North America. Salem, Mass. 1879.
13. Etter, Austin.
    Polyembryony developed under experimental conditions in certain polypodiaceous ferns. Bull. Torr. Bot. Club. 50: 95–106. 1923.
14. Farlow, W. G.
    An asexual growth from the prothallium of *Pteris cretica*. Quart. Jour. Mic. Sci. 14: 266–272. 1874.
15. Ferguson, Margaret G.
    Imbedded sexual cells in Polypodiaceæ. Bot. Gaz. 51: 443–447. Pls. 26, 27. 1911.
16. Flynn, Nellie F.
    Brief Note. Rhodora 13: 237–238. 1911.
17. Goebel, K.
    Aposporie bei *Asplenium dimorphum*. Flora 95: 243. 1905.
18. Griggs, R. F.
    A botanical survey of the Sugar Grove region. Ohio Biological Survey. Bull. 3. 1914.
19. Moseley, E. L.
    Sandusky Flora. Ohio State Acad. Sci. Special Papers No. 1.
20. Mottier, D. M.
    Notes on the sex of the gametophyte of *Onoclea Struthiopteris*. Bot. Gaz. 50: 209–213. 1910.
21. Pennell, Francis W.
    Asplenium angustifolium in Louisiana. Am. Fern. Jour. 3: 16–17. 1913.
22. Pfeiffer, Norma E.
    Abnormalities in prothallia of *Pteris longifolia*. Bot. Gaz. 53: 436–438. Figs. 1–4. 1912.

23. Pickett, F. L.
The development of the prothallium of *Camptosorus rhizophyllus*. Bot. Gaz. 57: 228–238. Figs. 1–41. Pls. XII, XIII. 1917.

24. Robinson, B. L., and Fernald, M. L.
Gray's new manual of botany. 7th edition. New York. 1908.

25. Schaffner, J. H.
Catalogue of Ohio vascular plants. Bull. 2. Ohio Biol. Surv. 1914.

26. Standley, Paul C.
The ferns of Greene County, Missouri. Am. Fern Jour. 6:44–51. 1916.

27. Steil, W. N.
Apogamy in *Pellea atropurpurea*. Bot. Gaz. 52: 400–401. 1911.

28. * * * Studies of some new cases of apogamy in ferns. Bull. Torr. Bot. Club 45: 93–108. Pls. 4, 5. 1918.

29. * * * Apospory in *Pteris sulcata* L. Bot. Gaz. 67: 469–482. Pls. XVI, XVII. Figs. 1–4. 1919.

30. * * * Vegetative reproduction and aposporous growths from the young sporophyte of *Polypodium irioides*. Bull. Torr. Bot. Club 48: 203–205. Figs. 1–3. 1921.

31. * * * The development of prothallia and antheridia from the sex organs of *Polypodium irioides*. Bull. Torr. Bot. Club 48: 271–276. Pl. IV, Figs. 1–4. 1921.

32. Tilton, George Henry.
The fern lover's companion. Melrose, Mass. 240 pp. 1922.

33. Tuttle, Mary Louise.
Fern trips in Virginia. Am. Fern Jour. 5: 108–113. 1915.

34. Woodburn, Wm. L.
A remarkable case of polyspermy in ferns. Bot. Gaz. 44: 227. Fig. 1. 1907.

35. Wuist, Elizabeth Dorothy.
The physiological conditions for the development of monoecious prothallia in *Onoclea Struthiopteris*. Bot. Gaz. 49: 216–219. 1910.

36. * * * Sex and development of the gametophyte of *Onoclea Struthiopteris*. Bot. Gaz. 56: 448. 1913. Review.

37. * * * Branched prothallia in the Polypodiaceæ. Bull. Torr. Bot. Club 43: 365–383. Figs. 1–15. 1916.

38. * * * Apogamy in *Phegopteris polypodioides* Fee, *Osmunda cinnamomea* L., and *O. Claytoniana* L. Bot. Gaz. 64: 435–437. 1917.

39. Yamanouchi, Shigeo.
Spermatogenesis, oogenesis and fertilization in *Nephrodium*. Bot. Gaz. 45: 145–175. Pls. 6–8. 1908.

40. * * * Apogamy in *Nephrodium*. Bot. Gaz. 289–318. Pls. 9, 10. Figs. 1–3. 1908.

41. Young, A. H.
Notes on certain species of the genus *Asplenium*. Botanical Bulletin, Vol. I, No. 1, Nov. 1875. (Later the Botanical Gazette.)

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1925*

JOHN H. SHAFFNER
Ohio State University

Many rare plants have been added to the State Herbarium of the Ohio State University during the past year, establishing new records and extending the known ranges of various species in the state. The names of the several contributors are given in connection with each record. Through the kindness of Dr. L. B. Robinson, Curator of the Gray Herbarium of Harvard University, 15 records are published of species and varieties represented in the Gray Herbarium. It is interesting to note that some of these plants were collected by Wm. S. Sullivant, the most prominent of the early botanists of Ohio.

Those who are interested in the correct phylogeny of our plants and the proper arrangement of the species in series will find the recent papers on the Chicory family and Carrot family of value, published in this Journal by Nellie F. Henderson.

25. *Asplenium ruta-muraria* L. Wall-rue Spleenwort. "At top of limestone Cliff." Cedar Falls, Adams Co. Mrs. Bayard Taylor.
55. *Equisetum silvaticum* L. Wood Horsetail. Ravenna, Portage Co. Raymond Dobbins.
60. *Lycopodium inundatum* L. Bog Club-moss. "Sand-pit." Holland, Lucas Co. E. L. Moseley.
65. *Selaginella apus* (L.) Spreng. Creeping Selaginella. On hillside marsh with Sphagnum, among grasses. White's Gulch, Liberty Twp., Jackson Co. Bedford Twp., and near Pomeroy, Meigs Co. Mrs. Bayard Taylor.
65.1. *Picea abies* (L.) Karst. Norway Spruce. "Naturalized from trees planted about 70 years ago. Trees of all ages from seedlings to about 50 years old are growing and forming a natural forest extending a third of a mile or more." On Phelps Creek, Huntsburg Twp., Geauga Co., near Ashtabula Co. line. Mrs. Bayard Taylor.
68. *Pinus strobus* L. White Pine. "Escaped along roadside 6 miles west of Buena Vista, in Green Twp., Adams

*Papers from the Department of Botany, The Ohio State University, No. 169.

Co. About 75 trees covering about three acres of very poor hillside soil. Trees vary in size from 4 in. to 12 in. in diameter and have a very thrifty appearance." Conrad Roth.

69. *Pinus rigida* Mill. Pitch Pine. "On south-west side of hill." Buchtel, Athens Co. Len Stephenson.

71. *Pinus echinata* Mill. Short-leaf Yellow Pine. Many trees on south-west exposure. Two miles southwest of Sugar Grove, Fairfield Co. John H. Schaffner. Also "on southwest side of hill." Buchtel, Athens Co. Len Stephenson.

76. *Taxus canadensis* Marsh. American Yew. "Under naturalized Picea abies (L.) Karst. Huntsburg Twp., Geauga Co. Near Ashtabula Co. line. Mrs. Bayard Taylor.

81. *Sagittaria graminea* Mx. Grassleaf Arrow-head. Spencer Twp., Lucas Co. E. L. Moseley.

140a. *Cyperus filiculmis macilentus* Fern. Cleveland, Cuyahoga Co. (Greenman). In Gray Herbarium.

143. *Cyperus flavescens* L. Yellow Cyperus. Spencer Twp., Lucas Co. E. L. Moseley.

146. *Kyllinga pumila* Mx. Low Kyllinga. Lucas Co. E. L. Moseley.

155. *Eleocharis tenuis* (Willd.) Schultes. Slender Spike-rush. Marshall Twp., Highland Co. Katie M. Roads.

159. *Fimbristylis autumnalis* (L.) R. & S. Slender Fimbristylis. Holland, Lucas Co. E. L. Moseley.

175. *Rynchospora capillacea* Torr. Capillary Beaked-rush. "Prairie patches." Turkey Creek, Adams Co. E. Lucy Braun.

177. *Rynchospora glomerata* (L.) Vahl. Clustered Beak-rush. Glengary Club grounds. Springfield Twp., Lucas Co. E. L. Moseley.

180. *Scleria pauciflora* Muhl. Papillose Nut-rush. Glengary Club grounds, Springfield Twp., Lucas Co. E. L. Moseley.

180a. *Scleria pauciflora caroliniana* (Willd.) Wood. Milan, Erie Co. (Moseley). In Gray Herbarium.

186. *Carex muricata* L. Lesser Prickly Sedge. Swanton, Fulton Co. E. L. Moseley.

195. *Carex diandra* Schr. Lesser Panicled Sedge. Castalia, Erie Co. E. L. Moseley.

241a. *Carex laxiflora patulifolia* (Dew.) Carey. Columbus, Franklin Co. (Gleason). Cleveland, Cuyahoga Co. (Beardslee). In Gray Herbarium.

276a. *Carex oederi pumila* (Coss. & Germ.) Fern. Castalia prairie, Erie Co. (Moseley). In Gray Herbarium.

291. *Carex typhina* Mx. Cat-tail Sedge. "Woods north of Nevada," Wyandot Co. E. L. Moseley.

298. *Bromus hordeaceus* L. Soft Chess. "Prairie patch." Turkey Creek, Adams Co. E. Lucy Braun.

300.1. *Bromus commutatus* Schrad. In Hillsboro and in Washington Twp., Highland Co. Katie M. Roads.

310.1. *Festuca obtusa* Spring. Blunt-glumed Fescue-grass. "Common in two woods in Washington Twp.," Highland Co. Katie M. Roads.

310.2. *Festuca rubra* L. Red Fescue-grass. Hillsboro, Highland Co. Katie M. Roads.

316. *Panicularia septentrionalis* (Hitchc.) Bickn. American Floating Manna-grass. Substitute this name for P. fluitans (L.) Ktz. and add to the record of distribution: "In pond, sweet gum-pin oak woods." Between White Oak and Sardinia, Brown Co. E. Lucy Braun.

321.1. *Uniola latifolia* Mx. Broad-leaf Spike-grass. On lower part of Ohio river bluff. Coal Grove, Lawrence Co. John H. Schaffner.

328. *Poa autumnalis* Muhl. Flexuous Spear-grass. In a wood near Hillsboro, Highland Co. Katie M. Roads.

334. *Eragrostis pectinacea* (Mx.) Steud. Purple Love-grass. Hillsboro, Highland Co. Katie M. Roads.

344. *Koeleria cristata* (L.) Pers. Crested Koeler-grass. Two miles north of Whitehouse, Lucas Co. E. L. Moseley.

347. *Triplasis purpurea* (Walt.) Chapm. Purple Sand-grass. Marblehead peninsula, Ottawa Co. E. L. Moseley.

351. *Danthonia compressa* Aust. Flattened Wild-oat-grass. Near Hillsboro, Highland Co. Katie M. Roads.

364. *Agropyron caninum* (L.) R. & S. Awned Wheat-grass. Two miles north of Whitehouse, Lucas Co. E. L. Moseley.

375. *Hordeum jubatum* L. Squirrel-tail Barley. This grass was seen on a trip through northwestern Ohio around Kenton, Hardin Co.; Lima, Allen Co.; Van Wert, Van Wert Co.; Paulding and Antwerp, Paulding Co.; Hicksville, Defiance Co.; and Bryan and Montpelier, Williams Co. John H. Schaffner.

378. *Capriola dactylon* (L.) Ktz. Bermuda-grass. "Well established on grassy slope, University of Cincinnati Campus." Cincinnati, Hamilton Co. E. Lucy Braun.
383. *Sporobolus asper* (Mx.) Kunth. Longleaf Rush-grass. Along New York Central R. R., Spencer Twp., Lucas Co. E. L. Moseley.
385. *Sporobolus neglectus* Nash. Small Rush-grass. "Prairie patches." Turkey Creek, Adams Co. E. Lucy Braun.
402. *Muhlenbergia racemosa* (Mx.) B. S. P. Marsh Muhlenbergia. Whitehouse, Lucas Co. E. L. Moseley.
409. *Stipa spartea* Trin. Porcupine-grass. North of Whitehouse, Lucas Co. E. L. Moseley.
419. *Panicum agrostoides* Spreng. Agrostis-like Panic-grass. Swanton Twp., Lucas Co. "Abundant in a low meadow." E. L. Moseley.
427. *Panicum philadelphicum* Bernh. Philadelphia Panic-grass. "Marly soil." Turkey Creek, Adams Co. E. Lucy Braun.
436. *Panicum boreale* Nash. Northern Panic-grass. Whitehouse, Lucas Co. E. L. Moseley.
446. *Panicum commutatum* Schultes. Variable Panic-grass. Washington Twp., Highland Co. Katie M. Roads.
452. *Syntherisma ischaemum* (Schreb.) Nash. Small Crab-grass. Along roadside. Haverhill, Scioto Co. John H. Schaffner.
456.1. *Paspalum circulare* Nash. Round-flowered Paspalum. Portsmouth, Scioto Co. Conrad Roth. Also at Coal Grove, Lawrence Co. John H. Schaffner.
481.1. *Hemerocallis flava* L. Yellow Day-lily. "On the roadside" near Hillsboro, Highland Co. Katie M. Roads.
481.2. *Nothoscordum bivalve* (L.) Britt. Yellow False-garlic. Springfield, Clark Co. (Sullivant, Semples). In Gray Herbarium.
484. *Allium cepa* L. Common Onion. Escaped along roadside. South Charleston, Clark Co. John H. Schaffner.
498. *Stenanthium robustum* Wats. Stout Stenanthium. "In swampy soil." White's Gulch, Liberty Twp., Jackson Co. Mrs. Bayard Taylor.
499. *Chamaelirium luteum* (L.) Gr. Chamaelirium. "On hillside." White's Gulch, Liberty Twp., Jackson Co. Mrs. Bayard Taylor.

500. *Triantha glutinosa* (Mx.) Baker. Glutinous Triantha. "Along New York Central R. R. ditch." Swanton Twp., Lucas Co. E. L. Moseley.

504. *Trillium declinatum* (Gr.) Gleason. Drooping Trillium. Maroon-flowered variety. Fort Hill, Highland Co. Katie M. Roads.

530. *Tradescantia reflexa* Raf. Reflexed Spiderwort. White's Gluch, Liberty Twp., Jackson Co. Mrs. Bayard Taylor.

544. *Juncus articulatus* L. Jointed Rush. Neapolis, Lucas Co. E. L. Moseley.

550. *Juncus scirpoides* Lam. Scirpus-like Rush. Whitehouse, Lucas Co. E. L. Moseley.

552.1. *Juncoides bulbosum* (Wood) Small. Bulb-bearing Woodrush. "Rather common in a wood" in Washington Twp., Highland Co. Katie M. Roads.

553. *Xyris flexuosa* Muhl. Slender Yellow-eyed-grass. Two miles north of Whitehouse, Lucas Co. E. L. Moseley.

557.1. *Iris germanica* L. Common Iris. Beside a swampy place containing Cat-tails in a grassy meadow. Spontaneous, either from seed or rhizomes. Near Columbus, Franklin Co. John H. Schaffner.

557.2. *Iris hexagona* Walt. Southern Blue-flag. Toledo, Lucas Co. (Young). In Gray Herbarium.

564. *Cypripedium reginae* Walt. Showy Lady's-slipper. Glengary Club grounds, Springfield Twp., Lucas Co. E. L. Moseley.

575. *Blephariglottis ciliaris* (L.) Rydb. Yellow Fringed-orchis. Two miles north of Whitehouse, Lucas Co. E. L. Moseley.

596. *Liparis loeselii* (L.) Rich. Fen Twayblade. "Sand pit," Holland, Lucas Co. E. L. Moseley.

600. *Corallorrhiza maculata* Raf. Large Coral-root. "In a beech wood," Washington Twp., Highland Co. Katie M. Roads.

601. *Corallorrhiza wisteriana* Conrad. Wister's Coral-root. Washington Twp., Highland Co. Katie M. Roads.

602. *Corallorrhiza odontorhiza* (Willd.) Nutt. Small-flowered Coral-root. Marshall Twp., Highland Co. Katie M. Roads.

604. *Magnolia tripetala* L. Umbrella Magnolia. White's Gulch, Liberty Twp., Jackson Co. "Abundant in the locality in the bottom and on talus slopes." Mrs. Bayard Taylor.

614. *Ranunculus repens* L. Creeping Buttercup. "Rare, the patch from which this plant was taken has maintained itself through several rotations of crops, but has not spread very much." Tyler Farm, Perry, Lake Co. F. J. Tyler.
618. *Ranunculus arvensis* L. Corn Crowfoot. Columbus, Franklin Co. "Introduce with packing material," (W. C. Werner). In Gray Herbarium.
619. *Ranunculus obtusiusculus* Raf. Lance-leaf Buttercup. "Shallow pools, pin oak woods." Between White Oak and Sardinia, Brown Co. E. Lucy Braun.
632. *Delphinium exaltatum* Ait. Fall Larkspur. "Prairie patches." Turkey Creek, Adams Co. E. Lucy Braun.
669.1. *Eschscholtzia californica* Cham. California Poppy. Spontaneous after cultivation and seeding abundantly. Columbus, Franklin Co. John H. Schaffner.
687. *Camelina sativa* (L.) Crantz. Common False-flax. "Cultivated fields." Perry, Lake Co. F. J. Tyler.
703. *Thlaspi arvense* L. Field Penny-cress. Columbus, Franklin Co. "First collected in the locality in 1918, persistent ever since." C. J. Willard.
719. *Barbarea verna* (Mill.) Aschers. Early Winter-cress. Portsmouth, Scioto Co. Conrad Roth.
733. *Cardamine rotundifolia* Mx. Roundleaf Bitter-cress. Ironton, Lawrence Co. Lillian E. Humphrey.
742.2. *Lunaria annua* L. Common Honesty. "Spreading from cultivation." Westerville, Franklin Co. W. H. Camp.
775. *Linum virginianum* L. Virginia Flax. Two miles north of Whitehouse, Lucas Co. E. L. Moseley.
809. *Chamaesyce rafinesqui* (Greene) Small. (Euphorbia hirsuta (Torr.) Wieg.). Hairy Spurge. Perkins, Erie Co. (Moseley), Painesville, Lake Co. (W. C. Werner). In Gray Herbarium. Holland, Lucas Co. E. L. Moseley.
817. *Malva sylvestris* L. High Mallow. Buchtel, Athens Co. Len Stephenson.
824. *Althaea rosea* L. Hollyhock. "General escape in waste places and along roadsides." Washington Twp., Highland Co. Katie M. Roads.
828.1. *Hibiscus syriaca* L. Shrubby Hibiscus. "Propagates itself readily from seed along streets and in waste places" near Hillsboro, Highland Co. Katie M. Roads.

836. *Hypericum kalmianum* L. Kalm's St. John's-wort. Neapolis, Lucas Co. E. L. Moseley.

846. *Hypericum majus* (Gr.) Britt. Large Canadian St. John's-wort. Neapolis, Lucas Co. E. L. Moseley.

848. *Hypericum drummondii* (Grev. & Hook.) T. & G. Drummond's St. John's-wort. "In a meadow." Fort Ancient, Warren Co.; Hillsboro, Highland Co. Katie M. Roads.

849. *Sarothra gentianoides* L. Orange-grass. "In a pasture lot." Hillsboro, Highland Co. Katie M. Roads. Buchtel, Athens Co. Len Stephenson.

850. *Triadenum virginicum* (L.) Raf. Marsh St. John's-wort. Morgan Swamp, Ashtabula Co. H. C. Beardslee and F. J. Tyler.

858. *Lechea leggettii* Britt & Holl. Spencer Twp., Lucas Co. E. L. Moseley.

858.1. *Lechea intermedia* Legg. Large-podded Pinweed. Spencer Twp., Lucas Co. E. L. Moseley.

873. *Viola pallens* (Banks) Brain. Woodland White Violet. Delaware Co. Rufus Crane.

875. *Viola affinis* Le Conte. Thinleaf-Blue Violet. "Swamp woods," Delaware Co. Rufus Crane. The annotation, "General and abundant," in the catalog is a printer's mistake. The above specimen is the only one in the herbarium at present.

884. *Viola sagittata* Ait. Arrowleaf violet. Portsmouth, Scioto Co. Conrad Roth.

912. *Silene latifolia* (Mill.) Britt. & Rend. Bladder Campion. On banks of Taylorsville Conservency dam, Montgomery Co. John H. Schaffner.

912.1. *Silene cserei* Baumg. (S. fabaria Sibth. & Son.). Balkan Campion. "Collected on Erie Dump about 2 miles west of Phalanx station. Evidently established." Phalanx, Trumbull Co. From Southeastern Europe. Almon N. Rood.

920. *Silene caroliniana* Walt. Carolina Catchfly. "In a cleft on a hillside at Fort Hill," Highland Co. Katie M. Roads.

955. *Chenopodium boscianum* Moq. Bosc's Goosefoot. New Philadelphia, Tuscarawas Co. V. Sterki.

963. *Kochia scoparia* (L.) Roth. Mock-cypress. Abundantly spontaneous in a field after cultivation. Columbus, Franklin Co. John H. Schaffner.

980. *Tracaulon arifolium* (L.) Raf. Halberd-leaf Tearthum. "Very abundant in the artificial ditches at Fort Ancient," Warren Co. Katie M. Roads.

983. *Persicaria amphibia* (L.) S. F. Gr. Water Persicaria. "Railroad bank north of Carey," Wyandot Co. E. L. Moseley.

995. *Polygonum buxiforme* Small. Shore Knotweed. Hillsboro, Highland Co. Katie M. Roads.

998. *Polygonum tenue* Mx. Slender Knotweed. Two miles north of Whitehouse, Lucas Co. E. L. Moseley.

1039.1. *Rosa rugosa* Thunb. Japanese Rose. "Escaped from cultivation." Beach of Lake Erie. Perry, Lake Co. F. J. Tyler.

1040.1. *Rosa canina* L. Dog Rose. From Europe. Escaped near Westerville, Franklin Co. W. H. Camp.

1090. *Prunus cuneata* Raf. Appalachian Cherry. North of Whitehouse, Lucas Co. E. L. Moseley.

1098. *Chamaecrista nictitans* (L.) Moench. Sensitive-pea. Buchtel, Athens Co. Len Stephenson and John H. Schaffner.

1131. *Robinia viscosa* Vent. Claminy Locust. Buchtel, Athens Co. Len Stephenson and John H. Schaffner.

1131.1. *Robinia hispida* L. Rose Acacia. Escaped from cultivation. Buchtel, Athens Co. Len Stephenson and John H. Schaffner.

1138. *Meibomia pauciflora* (Nutt.) Ktz. Few-flowered Tick-trefoil. Washington Twp., Highland Co. Katie M. Roads.

1138.1. *Meibomia arenicola* Vail. (Desmodium lineatum (Mx.). D C. Sand Tick-trefoil. Perkins, Erie Co. (Moseley). In Gray Herbarium. Prof. Moseley has found it recently north of Holland, Lucas Co.

1149. *Meibomia marylandica* (L.) Ktz. Maryland Tick-trefoil Springfield Twp., Lucas Co. E. L. Moseley.

1150. *Meibomia obtusa* (Muhl.) Vail. Ciliate Tick-trefoil. Glengary Club grounds, Springfield Twp., Lucas Co. E. L. Moseley.

1153. *Lespedeza nuttallii* Darl. Nuttall's Bush-clover. "Clearings and shale slopes." Turkey Creek, Adams Co. E. Lucy Braun.

1157. *Lespedeza virginica* (L.) Britt. Slender Bush-clover. On clearings and shale slopes." Mineral Springs, Adams

Co. E. Lucy Braun. Also Chesapeake, Lawrence Co. R. B. Gordon.

1158. *Lespedeza simulata* Mack. & Bush. Intermediate Bush-clover. Castalia, Erie Co. (Moseley). In Gray Herbarium.

1161.1. *Vicia villosa* Roth. Hairy Vetch. Appears to be quite generally escaped in the state and is persistent in fields after cultivation. A weed in wheatfields.

1173.1. *Lathyrus latifolius* L. Everlasting Pea. "Escaped from cultivation along roadsides." Hillsboro, Highland Co. Katie M. Roads.

1173.2. *Clitoria mariana* L. Butterfly-pea. White's Gulch, Liberty Twp., Jackson Co. "On sandy banks under pine trees." Mrs. Bayard Taylor.

1199. *Parsonsia petiolata* (L.) Rusby. Blue Waxweed. "Creek bottom." Perry, Lake Co. F. J. Tyler.

1200. *Rhexia virginica* L. Virginia Meadow-beauty. Blue Creek, Adams Co. Conrad Roth.

1286. *Alnus incana* (L.) Wild. Hoary Alder. In swampy place. Loudonville, Ashland Co. Cedar Swamp, Champaign Co. John H. Schaffner. Also Western part of Lucas Co. E. L. Moseley.

1338. *Epilobium lineare* Muhl. Linear-leaf Willow-herb. Morgan Swamp, 5 miles east of Hartsgrove, Ashtabula Co. H. C. Beardslee and F. J. Tyler.

1342. *Convolvulus spithamaeus* L. Upright Bindweed. Ironton, Lawrence Co. Lillian E. Humphrey.

1344. *Raimannia laciniata* (Hill.) Rose. Cutleaf Evening-primrose. Whitehouse, Lucas Co. E. L. Moseley.

1357.1. *Cucurbita lagenaria* L. Bottle Gourd. "Accidental along road," Hillsboro, Highland Co. Katie M. Roads.

1376. *Steironema lanceolatum* (Walt.) Gr. Lanseleaf Yellow Loosestrife. North of Whitehouse, Lucas Co. E. L. Moseley.

1395. *Azalea lutea* L. Flame Azalea. Ironton, Lawrence Co. Lillian E. Humphrey.

1401. *Oxydendrum arboreum* (L.) DC. Sorrel-tree. Buchtel, Athens Co. Len Stephenson.

STYRACACEÆ. Storax Family.

1415.1. *Styrax grandifolia* Ait. Large-leaf Storax. "On the crest of the north end of a high ridge, near 'Buffalo Beat,' on an outcropping ledge of limestone." Buchtel, Athens Co. Len Stephenson.

1455. *Chionanthus virginica* L. Fringetree. Liberty Twp., Jackson Co. Mrs. Bayard Taylor.

1464. *Gentiana quinquefolia* L. Stiff Gentian. Cedar Falls, Adams Co. Mrs. Bayard Taylor.

1465. *Gentiana crinita* Froel. Fringed Gentian. Grand River Valley, Madison, Lake Co. H. C. Beardslee and F. J. Tyler.

1470. *Gentiana villosa* L. Striped Gentian. "Open woods." Cedar Falls, Adams Co. Mrs. Bayard Taylor.

1472. *Obolaria virginica* L. Pennywort. Near Hillsboro, Highland Co. Katie M. Roads.

1481. *Acerates floridana* (Lam.) Hitch. Florida Milkweed. On hillsides, Buchtel, Athens Co. Len Stephenson. Also Whitehouse, Lucas Co. E. L. Moseley.

1481.1. *Asclepiodora viridis* (Walt.) Gr. Oblong-leaf Green Milkweed. Cedar Mills, Adams Co. Conrad Roth.

1484. *Asclepias purpurascens* L. Purple Milkweed. Sugar Grove, Fairfield Co. On open hillside. John H. Schaffner. Also Minford, Scioto Co. Conrad Roth.

1488. *Asclepias amplexicaulis* J. E. Sm. Blunt-leaf Milkweed. Sandy Springs, Adams Co. Conrad Roth.

1500a. *Datura stramonium* L. Jimson-weed. Purple-stemmed variety. General in the state.

1500b. *Datura stramonium* L. Jimson-weed. Smooth-podded variety. Escaped from cultivation. Columbus, Franklin Co. John H. Schaffner.

1529. *Conobea multifida* (Mx.) Benth. Conobea. "On limestone." Greenbrier District, Adams Co. Conrad Roth.

1555. *Dasystoma virginica* (L.) Britt. Smooth False Foxglove. "Openings, pin oak woods." Westboro, Clinton Co. E. Lucy Braun.

1561. *Castilleja coccinea* (L.) Spreng. Scarlet Painted-cup. "Meadows and thickets, along streams." Turkey Creek, Adams Co. E. Lucy Braun. Greenbrier District, Adams Co. Conrad Roth.

1568. *Chaenorrhinum minus* (L.) Lange. Lesser Toadflax. "Railroad tracks," Westboro, Clinton Co. E. Lucy Braun. Also north of Carey, Wyandot Co. E. L. Moseley and V. F. Alspach. Also Perry, Lake Co. F. J. Tyler.

1570. *Kickxia elatine* (L.) Dum. Sharp-pointed Toadflax. Chesapeake, Lawrence Co. R. B. Gordon.

1597.1. *Myosotis micrantha* Pallas. Small-flowered Forget-me-not. Naturalized from Europe. Ashtabula, Ashtabula Co. (Sara F. Goodrich, no. 552). In Gray Herbarium.

1607. *Echium vulgare* L. Blueweed. Abundant in pastures and along roads. South Charleston, Clark Co. John H. Schaffner.

1627. *Scutellaria integrifolia* L. Hyssop Skullcap. Portsmouth, Scioto Co. Conrad Roth.

1641.1. *Koellia leptodon* (Gr.) Small. (Pycnanthemum leptodon Gr.). Springfield, Clark Co. (Sullivant). In Gray Herbarium.

1653. *Mentha citrata* Ehrh. Bergamot Mint. Buchtel, Athens Co. Len Stephenson.

1669.1. *Leonurus marrubiastrum* L. Hoarhound Motherwort. "In fields." Naturalized from Europe. Milford, Clermont Co. E. Lucy Braun.

1681. *Monarda punctata* L. Horsemint. "Sandy soil." Bowling Green, Wood Co. E. L. Moseley.

1686. *Salvia lyrata* L. Lyreleaf Sage. White's Gulch, Liberty Twp., Jackson Co. Mrs. Bayard Taylor.

1698. *Aralia spinosa* L. Angelica-tree. Escaped from cultivation. Buchtel, Athens Co. Len Stephenson and John H. Schaffner.

1704. *Eryngium aquaticum* L. Rattlesnake-master. "Level, poorly drained fields." California, Hamilton Co. E. Lucy Braun.

1714.1. *Hipposelinum levisticum* (L.) Britt. Lovage. "Along a fence in a waste lot." Escaped from cultivation in Penn Twp., Highland Co. From S. Europe. Katie M. Roads.

1722.1. *Thaspium pinnatifidum* (Buckl.) Gr. Cutleaf Meadow-parsnip. "Lower slope of railroad embankment, level upland." Hamlet, Clermont Co. E. Lucy Braun.

1734. *Eulophus americanus* Nutt. Eastern Eulophus. Columbus, Franklin Co. (Sullivant. "Extremely rare"). In Gray Herbarium.

1735. *Pimpinella saxifraga* L. Pimpernel. Sycamore, Wyandot Co. (Rusby, 1878). In Gray Herbarium.
1753. *Houstonia ciliolata* Torr. Fringed Houstonia. Hillsboro, Highland Co. Katie M. Roads.
1760. *Diodia teres* Walt. Rough Buttonweed. Chesapeake, Lawrence Co. R. B. Gordon.
1776.1. *Viburnum molle* Mx. Soft-leaf Arrow-wood. "Beaver pond flat," Adams Co. E. Lucy Braun. In Herbarium, University of Cincinnati.
1794. *Lonicera japonica* Thunb. Japanese Honeysuckle. Escaped from cultivation and spreading at Buchtel, Athens Co. Len Stephenson and John H. Schaffner.
1800. *Lonicera dioica* L. Smooth-leaf Honeysuckle. Whitehouse, Lucas Co. E. L. Moseley.
1817. *Lobelia puberula* Mx. Downy Lobelia. Shawnee Forest Preserve, Union Twp., Scioto Co. Conrad Roth.
1834. *Rudbeckia fulgida* Ait. Orange Cone-flower. "Fields." Blanchester, Clinton Co. E. Lucy Braun.
1835a. *Rudbeckia speciosa* sullivanti (Boy. & Bead.) Rob. Columbus, Franklin Co. (Sullivant). In Gray Herbarium.
1840. *Helianthus occidentalis* Ridd. Fewleaf Sunflower. "Prairie ridge on Cedarville marl." Turkey Creek, Adams Co. E. Lucy Braun.
1857. *Phaethusa helianthoides* (Mx.) Britt. Sunflower Crownbeard. Washington Twp., Highland Co. Katie M. Roads.
1873. *Bidens aristosa* (Mx.) Britt. Western Tickseed. Springfield Twp., Lucas Co. E. L. Moseley.
1876. *Polymnia uvedalia* L. Yellow Leaf-cup. "Apparently introduced into the locality recently." Two and one-half miles north of New Philadelphia, Tuscarawas Co. V. Sterki.
1886. *Helenium nudiflorum* Nutt. Purple-headed Sweezeweed. "Growing abundantly in an old pasture." Perry, Lake Co. F. J. Tyler.
1901. *Grindelia squarrosa* (Pursh) Dun. Broadleaf Gumplant. "Engle's pasture next to Wabash R. R." South of Swanton, Fulton Co. E. L. Moseley.
1903. *Chrysopsis mariana* (L.) Nutt. Maryland Golden-aster. Shawnee Forest Preserve, Union Twp., Scioto Co. Conrad Roth.

1909. *Solidago erecta* Pursh. Slender Goldenrod. Mineral Springs, Adams Co. E. Lucy Braun.

1922. *Solidago rigida* L. Stiff Goldenrod. "Prairie patches." Turkey Creek, Adams Co. E. Lucy Braun.

1929. *Sericocarpus linifolius* (L.) B. S. P. Narrowleaf Whitetop Aster. "Oak-blueberry association. Sandy ridge." Peach Mt., Adams Co. E. Lucy Braun.

1934. *Aster azureus* Lindl. Azure Aster. "Steep clay bluffs, prairie openings." Miamiville, Clermont Co. E. Lucy Braun.

1941. *Aster patens* Ait. Late Purple Aster. Portsmouth, Scioto Co. Conrad Roth.

1948. *Aster junceus* Ait. Rush Aster. Lucas Co. E. L. Moseley.

1951. *Aster vimineus* Lam. Small White Aster. Buchtel, Athens Co. Len Stephenson.

1957. *Aster faxoni* Porter. Faxon's Aster. Marblehead peninsula, Ottawa Co. E. L. Moseley.

1976.1. *Eupatorium incarnatum* Walt. Pink Thoroughwort. Chesapeake, Lawrence Co. R. B. Gordon.

1977. *Eupatorium coelestinum* L. Mist-flower. Along roadside, just below Chillicothe, Ross Co. John H. Schaffner.

1982. *Lacinaria scariosa* (L.) Hill. Large Blazing-star. "Prairie patches," Turkey Creek, Adams Co. E. Lucy Braun.

1987. *Vernonia missurica* Raf. Missouri Ironweed. Whitehouse, Lucas Co. E. L. Moseley.

2019.1. *Carduus acanthoides* L. Spiny Plumeless Thistle. Near Ashville, Pickaway Co. F. H. Parks. Also near Urbana, Champaign Co. D. D. Dowds.

2035.3. *Apargia autumnale* (L.) Hoffm. Autumnal Hawkbit. The plant is the Var. *pratensis*. Trumbull, Ashtabula Co. Collector, Earl Dodge. F. J. Tyler.

2039. *Sonchus arvensis* L. Field Sow-thistle. "Rare but widely distributed in the country. Usually growing in rich low ground near railroads." Tyler Farm, Perry, Lake Co. F. J. Tyler.

2046. *Lactuca sagittifolia* Hill. Arrow-leaf Lettuce. Hillsboro, Highland Co. and Fort Ancient, Warren Co. Katie M. Roads.

2054. *Nabalus crepidineus* (Mx.) DC. Corymbed Rattlesnake-root. On Little Darby Creek, South of National Road, Madison Co. R. B. Gordon.

2064. *Crepis capillaris* (L.) Wallr. Smooth Hawksbeard. "Lawns in Perry Village." Perry, Lake Co. F. J. Tyler.

Date of Publication, June 4, 1926.

WANTED!

THE OHIO JOURNAL OF SCIENCE

VOL. XXII, NO. 6, APRIL, 1922

If any of those to whom the Journal comes do not care to keep their files complete, we shall be glad to receive their copies of the issue mentioned above.

Please send them to

MRS. ETHEL M. MILLER,
Botany and Zoology Building,
Ohio State University, Columbus